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Frontispiece. Two and one-half year old buck collected on August 26, 1959. Note antler development and faded summer pelage.

Photo by Denis Fillion

THE UNIVERSITY OF ALBERTA

THE ECOLOGY OF THE MULE DEER OF THE SHEEP RIVER REGION

A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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by

DAVID HENRY SHEPPARD

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ABSTRACT

An ecological study of the Rocky Mountain mule deer, Odocoileus hemionus hemionus (Rafinesque) was conducted from May, 1957 to May, 1960 at the Alberta Biological Station, 18 miles west of Turner Valley, Alberta, on the Sheep River. The vegetation, drainage, topography and extent of the study area are described.

Some weights and measurements of Rocky Mountain mule deer are provided and the annual pelage changes are discussed.

A population estimate was made on the basis of spring counts. The adult sex ratio for the three years averaged 29 males per 100 females. The over-winter survival of fawns was found to be low when compared with other areas. Fawn survival figures are provided.

Parturition and the growth and development of fawns are discussed. The peak of the fawning period was found to be the second week in June. Productivity information, based on fawn counts taken in August, is presented.

The growth of antlers and the seasonal variation in the size of mule deer groups are described.

Four mule deer were trapped and tagged. These provided some information on spring and summer movements.

The daily activity patterns of mule deer are discussed and notes on mule deer behavior are briefly presented.

Food and feeding habits are discussed in detail, with particular emphasis on the spring and summer periods. Browse surveys and browse tagging served to indicate which browse species were the most

important winter foods of big game mammals in the area. The range was found to lack a palatable, abundant browse plant.

Two mineral cafeterias were constructed but provided inconclusive results.

The relationship of mule deer to other animals in the environment, including competing species, is presented.

Mortality figures for the years 1957 to 1960 are given and the sex and age composition of mule deer mortality in the area are discussed. The causes of mortality are described.

It was concluded that the increase of mule deer in the Sheep River region was limited by the over-utilization of the winter food supply. The reduction of the mule deer, moose, and elk populations to within the carrying capacity of the range was recommended.

Acknowledgments

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INTRODUCTION

An ecological study of the Rocky Mountain mule deer, Odocoileus hemionus hemionus (Rafinesque), was begun in the Sheep River region in May of 1957. The purpose of the study was to arrive at an estimate of the mule deer population in the Sheep River area and to obtain information on movements, feeding habits, productivity, mortality, and limiting factors with a view to future mule deer management in the area. Most of the material was collected during the summers of 1957, 1958, and 1959. Observations were made from May 5 to September 15 of each year. In addition, short trips were made to the study area from November 11 to 14, 1959 and from April 28 to May 9, 1960.

The centre of the study area was the Alberta Biological Station located approximately 18 miles west of Turner Valley in the Sheep River District of the Bow River Forest Reserve. The area is representative of typical Alberta foothills habitat on the east slope of the Rocky Mountains and is accessible by forestry road.

The study was commenced under the direction of the late Dr. R. B. Miller of the Department of Zoology of the University of Alberta in cooperation with the Alberta Fish and Game Branch. From January to August, 1958, the study was supervised by Dr. J. E. Moore. The latter portion of the study was accomplished under the direction of Dr. V. Lewin.

In 1957, the study was financed by the University of Alberta and in 1958 and 1959 by a Canadian Industries Limited Wildlife

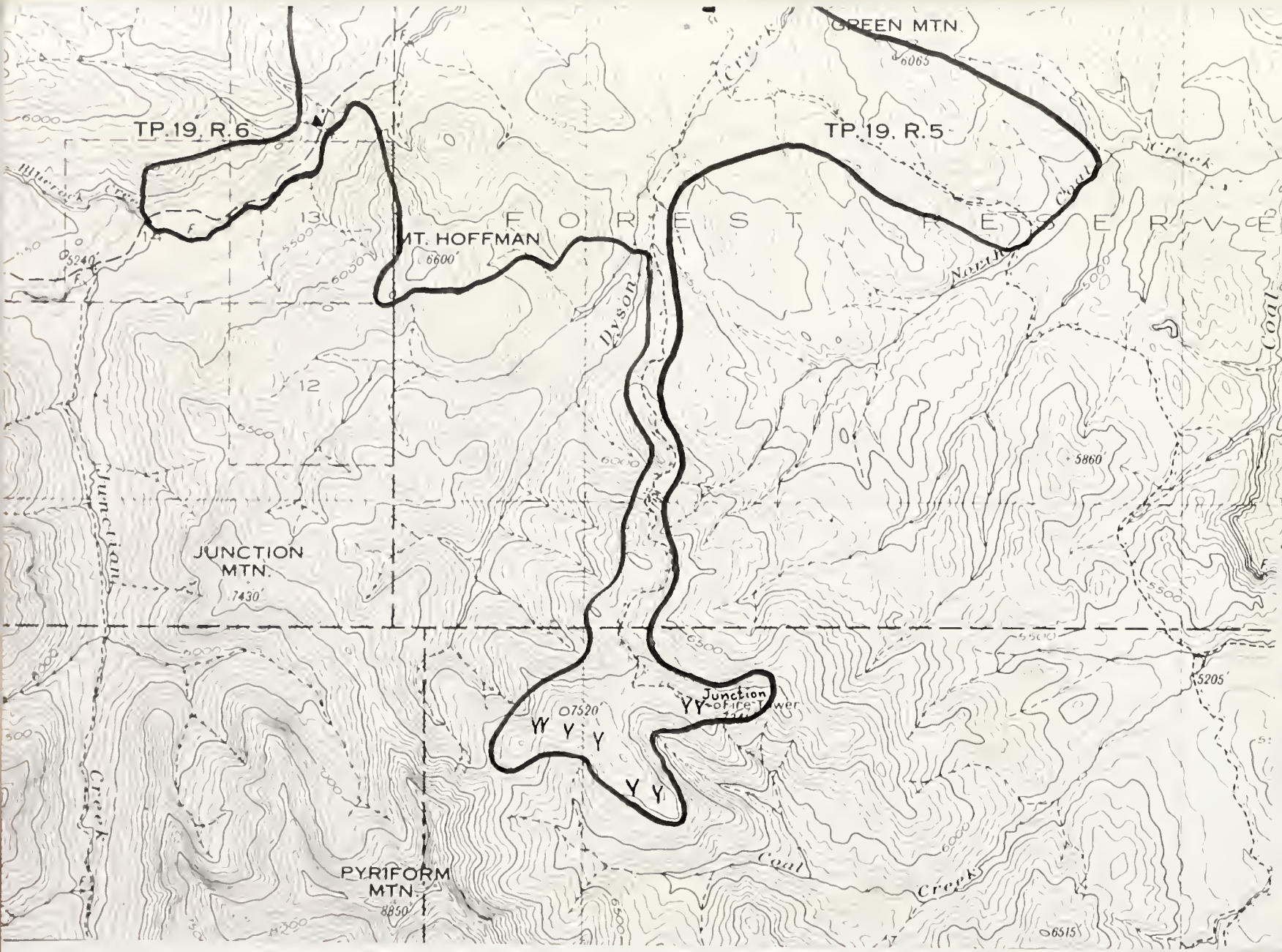
Fellowship. Expenses were shared by the Alberta Department of Lands and Forests and by the Department of Zoology.

HISTORY

According to Denny (1905), the Sheep River and the Highwood River regions formed a portion of the hunting territory of the Stoney Indians in the early nineteenth century. These Indians hunted along the Rocky Mountains as far south as northern Montana and were efficient hunters of big game animals of all types. The same author (Denny, 1956) states that, in the early days, deer were most common in the foothills of the Rocky Mountains and in other hilly country. They were also abundant in the river valleys extending onto the plains (Denny, 1905).

Ranching first became established in the Sheep River area in 1880 (Berry, 1953) and seemed to be coincident with the decrease of mule deer and other big game species, probably from overhunting (Rowan, 1952). It seems likely that deer living in the foothills and mountains would be the last to be heavily hunted and may have been fairly abundant until the early part of the twentieth century. Denny (1905) reports that by 1878 deer and elk were seen only in the mountains. According to Cowan (1945) game was very scarce in the Rocky Mountain region of Alberta in 1912. Fowler (1937) stated that moose and elk seemed to be increasing in the Highwood Range, part of which extends into the Sheep River District. However, he failed to mention the condition of the mule deer population in 1937 but presumably it, too, was on the increase. Lumbering in the Sheep River area was extensive during the first forty years of the twentieth century and doubtless represented an additional drain on the wildlife of the

area. During this same period, fires swept large portions of the study area. The last fire occurred about 1943. At present, the mule deer population of the Sheep River region is quite stable, having exceeded the upper limit of the carrying capacity of the area.



MAP 724A

DYSON CREEK

WEST OF FIFTH MERIDIAN

ALBERTA

Fig. 1. Map of study area with location of discarded antlers and mineral licks.

Symbols:

▲ stock lick

● natural lick

Y discarded antler

——— boundary of study area

SCALE: 1 inch to 1 mile

ALLSMOKE MTN.
6908'
Threepoint Creek
VOLCANO RIDGE
Rock Cr.
Volcano
6980'
TP. 20, R. 6
TP. 20, R. 5
TP. 20, R. 4
Ware Creek
Link Creek
Valley Cr.
5605'
4625'
5825'
5940'
6070'
5200'
5275'
4425'
SOUTH VOLCANO RIDGE
MISSINGLINK MTN.
6340'
MT. WARE
Creek
Gorge Creek
DOT MTN.
Dead Horse Creek
Bighorn Ranger Sta.
4750'
5705'
Canyon Creek
5775'
Sheep
Creek
March Creek
Creek
MT. McNAB
5520'
GREEN MTN.
6065'
TP. 19, R. 6
TP. 19, R. 5
TP. 19, R. 4
Creek
Creek
MT. HOFFMAN
ROCKY MOUNTAINS
FOREST RESERVE
6030'
4705'
5840'
31
32
29
28
20
21
30
19
13
14

DESCRIPTION OF THE STUDY AREA

The major portion of the study area is outlined on the map (Fig. 1.). Some of the study area extended slightly farther west than shown on the map. The point of this extension is indicated by arrows on the boundary line. In addition, some observations were made in the Burns' Mine area, seven miles west of the junction of Bluerock Creek with the Sheep River, at an altitude of 6,000 to 6,500 feet. The main study area covered an area of 45 square miles.

The topography of the region is very rough, most of the area being composed of high foothills which often exhibit rocky outcroppings near the top and small talus accumulations below. Adding further to the impression of ruggedness are the deep canyons cut into the shale strata by the Sheep River and by Gorge, Dyson, and Canyon Creeks (see map, Fig. 1.). Altitudes vary from 4,500 feet on the eastern edge of the area to 7,500 feet just west of Junction Lookout.

The area is drained largely by the Sheep River and its tributaries, the chief of which are Junction, Bluerock, Gorge, Dyson, Canyon, and Coal Creeks. The northern extremity of the area is drained by Ware Creek, a tributary of the North Sheep River.

Most of the study area has been burned within the present century and is in an early stage of lodgepole pine (Pinus contorta var. latifolia) to white spruce (Picea glauca) succession (see Fig. 2). Small areas which escaped the fires exist in the valleys and in the

Fig. 2. Lodgepole pine habitat on the south branch of Gorge Creek .

Fig. 3. Vegetation of the northwest slope of Missinglink Mountain

southwest corner of the study area. Logging was once quite extensive but is confined to post-cutting at present. In general, north and east slopes are heavily forested (see Fig. 3) while south and west slopes maintain varying mixtures of grassland, aspen poplar (Populus tremuloides), and lodgepole pine vegetation (see Fig. 4). At the high elevations on the western edge of the study area, the vegetation changes to alpine meadow, alpine fir (Abies lasiocarpa), and Engelmann spruce (Picea engelmannii). The Burns' Mine area is also alpine, the chief types of vegetation being alpine meadow and alpine forest composed of alpine fir, alpine larch (Larix lyallii), and Engelmann spruce (see Fig. 5). It was estimated that lodgepole pine vegetation covered 70 percent, aspen poplar, 10 percent, and mixtures of the two types, eight percent of the study area. All other vegetative communities comprised 12 percent of the total composition.

No yearly meteorological data are available for the Sheep River region but precipitation is moderate, possibly about 25 inches per year. In winter, snow accumulates in low areas to a depth of several feet while ridges may be swept relatively free by westerly winds. Snowfall has been recorded at the Alberta Biological Station during every month except July. Quite heavy snows are not uncommon in May and early June.

Fig. 4. Vegetation of the southwest slope of Dot Mountain. Groves of aspen poplar are scattered through areas of grassland.

Fig. 5. Alpine community near the headwaters of the Sheep River. Elevation 6,500 feet.

DESCRIPTION

In winter pelage the sides of the Rocky Mountain mule deer are cinnamon-buff, while the dorsal surface is a darker brown. In the adult male the forehead has a V-shaped area of dark brown hair, outlined anteriorly by light brown to white hair above the eyes and on the nose. In the female, the forehead is not as dark nor is it delineated sharply from the rest of the face (Fig. 7). The ears are gray outside and white inside with a blackish rim. The brisket is dark, almost black, shading to a lighter color on the sides (Fig. 7). Throat, belly, and inner sides of the legs are white, while the lower legs are buffy brown. A large white rump patch encircles the tail which is short, white dorsally, naked ventrally, and is tipped with a tuft of black hair (Fig. 6).

The summer pelage (Frontispiece and Fig. 8) is reddish-brown but more yellow than that of the white-tailed deer. The dorsal mid-line is darker and the forehead is not noticeably different from the rest of the face. The ears are white inside, yellowish outside, and are margined with dark brown. The underparts are pale yellow to almost white.

At all seasons, the metatarsal gland on the outer surface of the hindfoot and the tarsal gland on the inner side of the heel joint are distinguished by tufts of longer hairs.

The pelage of the fawn is reddish brown but somewhat darker than that of the doe. The back and sides are marked by six irregular rows of white spots with additional spots scattered between the rows.

Fig. 6. Adult doe in winter coat. Note tail, naked ventrally, white rump patch, and postero-ventral pelage.

Fig. 7. Anterior view of doe seen in Fig. 6 showing dark chest and brisket and absence of contrasting colors on the head and face.

DISTINGUISHING FEATURES

The Rocky Mountain mule deer can be distinguished from the white-tailed deer by several criteria. The antlers of the mule deer are dichotomously branched (see Fig. 8) while those of the white-tailed deer branch from a single main beam. The tail of the mule deer is small, white dorsally, naked below, and black-tipped while that of the white-tailed deer is buff above, and is often carried erect in flight. The tail of the Columbian black-tailed deer is also larger than that of the mule deer but is black dorsally. Mule deer have a peculiar bounding gait in which all four feet leave the ground at once. The white-tailed deer displays a running, rather than a bounding, gait. The final criterion concerns the relative lengths of the metatarsal glands. In the mule deer the metatarsal gland averages five inches in length compared with three inches in the Columbian black-tailed deer and one inch in the white-tailed deer. (Couan, in Taylor, 1956).

Fig. 8. Adult buck in summer pelage on July 12, 1959, showing dichotomous branching of the antlers.

Photo by Glen Adams

WEIGHTS AND MEASUREMENTS

A number of weights and measurements of mule deer of various ages were collected during the course of the study and are presented in Table I. Seven of the deer measured were collected by shooting, one was found dead, one was trapped and subsequently released, and six were taken by hunters in November of 1959. The method of aging followed that of Taylor (1956). The mule deer were classed as fawns until the second molar had fully erupted and as yearlings until the third molar had erupted and the temporary premolars had been replaced. Adult deer were those with a full complement of teeth.

The tail was measured from the anterior end of the first caudal vertebra to the posterior end of the last, while the ear measurement was taken from the notch to the tip. When total length was taken, the animal was stretched as straight as possible and was measured from the tip of the nose to the posterior end of the last caudal vertebra.

Weights in all cases are total weights as opposed to dressed weights. There was, however, some variation in the manner of weighing. All deer were weighed whole, with the exception of the buck collected August 26, 1959. This animal was degutted and quartered and the various pieces were weighed separately. Blood loss was not taken into account.

Adult males averaged larger in all measurements than did adult females, although there was some overlap in each measurement. The weight of the mule deer varied a great deal during the year. In the summer considerable weight was added, presumably because of better

Table I. Weights and measurements of Sheep River mule deer.

Date	Age and sex	Hind foot (in.)	Tail (in.)	Ear (in.)	Total length (in.)	Metatarsal gland (in.)	Total weight (lb.)
May 14, 1957	adult, male	19½	9	8½	74½	-	137
September 4, 1958	adult, male	19½	5	8½	66	5	-
July 19, 1959	adult, male	19	7½	8	-	5½	-
August 26, 1959	2½ years, male	20	9	8	-	5½	180
Averages		19½	7½	8¼	70¼	5¼	158½
May, 1956	adult, female	-	-	-	-	-	120
May 8, 1958	adult, female	18½	7	8½	61	6	135
June 10, 1959	adult, female	18½	5½	7¾	-	-	-
November 12, 1959	adult, female	18	7½	-	-	-	-
November 12, 1959	adult, female	-	-	8	-	-	-
November 12, 1959	adult, female	19½	-	8	-	5	-
November 12, 1959	adult, female	18½	8	7½	-	5	-
November 12, 1959	adult, female	18½	5½	7½	-	5½	-
Averages		18½	6¾	8	61	5	127½
May 8, 1958	foetus, female (160 days)	6¼	1¾	2¾	18¾	1¾	4
May 8, 1958	foetus, female (160 days)	6¼	2	2¾	18¾	1¾	4
May 14, 1958	11 months, female	18	7¼	8	56½	5	74
November 12, 1959	1½ years, male	19	7	7	-	5	-
November 12, 1959	1½ years, male	-	-	9	-	-	-

nutrition provided by green forage. On the basis of the few weights taken and the examination of other deer, the fall weights of mature adult bucks are estimated to be 225 pounds and those of adult does 175 pounds. Spring weights of adult bucks may range from 150 to 200 pounds. The one male which was weighed in the spring was found dead in a severely undernourished state and weighed only 137 pounds. A winter weight loss of one-quarter to one-third of the fall figure seems to be a common fluctuation.

PELAGE CHANGES

Mule deer in the Sheep River area begin to shed the gray winter coat by the first week in May but the red summer coat does not begin to show until the second week in June. Some deer appear uniformly red by the end of the third week in June. After the first week in July all deer show the red pelage of summer. An adult male collected on July 19, 1959, still had a few broken winter hairs on the chest region, hidden by the red summer hair.

By the last week in August, the gray winter coat grows in beneath the summer hair but does not become apparent at a distance until the first week in September. In general, adults are the first to shed, while yearlings are about two weeks later. Bucks are often the earliest to show pelage changes, with adult does shedding soon after. There is some overlap however. Table II presents observations of coat color showing the two periods of pelage change (after a scheme by Leopold et al, 1951). Deer included in the transition groups are those which appeared partly, but not entirely, gray when observed at close range.

Table II. Seasonal pelage changes in Sheep River mule deer.

Period	Coat color							
	Gray		Gray-red transition		Red		Red-gray transition	
	Number	%	Number	%	Number	%	Number	%
May 1 to 15	1469	100						
May 16 to 31	687	100						
June 1 to 15	12	80	3	20				
June 16 to 30			5	39	8	61		
July 1 to 15			2	13	14	87		
July 16 to 31					89	100		
August 1 to 15					62	100		
August 16 to 31					74	100		
September 1 to 15	4	31			7	54	2	15

THE POPULATION ON THE STUDY AREA

Estimate

During the months of April and May, the mule deer on the study area could be counted with comparative ease. At that time of year, most of the deer feed on grassy southwest slopes, attracted by the appearance of the first green grass. Visibility is optimum during most of this period because trees and shrubs do not come into leaf until the middle of May. Since the author did not arrive on the study area until the early part of May each year, the most satisfactory counting conditions were limited to a period of about two weeks, from May 5 to May 20. The best times of the day for counting were early morning until about 10:00 A. M. and evening from 5:00 P. M. until dark, depending on the temperature. On hot days, intensive feeding was apt to finish earlier in the morning and commence later in the evening. Some feeding occurs throughout the day at that time of year. Table III summarizes the spring population estimates for the years 1957 to 1959. In order to arrive at an estimate, the area was subdivided into zones based on natural landmarks and vegetation. The three highest counts on each zone were averaged and this average increased by one-fifth to include deer not seen. The mule deer population in zones difficult to survey was estimated from counts made in similar habitats. The total for all zones was rounded off to the nearest 25 animals to provide the population estimate.

Table III. Population estimates, 1957 to 1959.

Year	Estimated population on study area	Deer per square mile
1957	250	5.6
1958	300	6.7
1959	325	7.2

The population was lowest in May of 1957 following a severe die-off in the winter of 1956-57 (see the section on mortality, p. 85), then rose steadily during the next two years, when winter mortality was light. The density figures derived from the population estimates range from 5.6 deer per square mile in 1957 to 7.2 deer per square mile in 1959. These figures are lower than the mule deer density of 10 per square mile found by Hanson and McCulloch (1955) in Arizona and shrink to insignificance in comparison with the density of Columbian black-tailed deer, Odocoileus hemionus columbianus, studied in Lake County, California by Dasmann and Taber (1956 a). The latter obtained pre-fawning density figures ranging from 55 to 90 deer per square mile. The low density figures found in the Sheep River study are believed to be attributable to the effects of an impoverished winter range with only a small supply of choice browse species.

The population estimates arrived at are believed to be conservative, but not overly so. However, a possible source of error may be involved. Repeated observations indicated that some deer never

join the larger feeding groups, but forage singly or in small groups in denser cover, such as that provided by lodgepole pine. This factor was taken into account when the final estimates were made.

Herd Composition

The first two weeks in May also proved the best period to obtain information on the sex and age composition of the herd. The buck deer have shed their old antlers before that time but are easily recognized on the basis of several characters. Bucks can be distinguished by means of the newly growing antlers, which are one-fourth to one-half of an inch in length, the broad forehead, and the dark brown patch of hair on the forehead contrasted with the white of the lower face. In addition, the ears of bucks are often held in a more lateral position than are those of does. Fawns were separated quite accurately from adults on the basis of size alone. The head of the fawn (which is 10 to 11 months old at this time) appears considerably shorter than that of the adult. It was found to be very difficult to sex fawns in May because the male fawns show little antler development and do not have any of the other marked sexual characteristics shown by adult males.

A group of deer was only included in the final tabulations if all of its members had been sexed and aged. Table IV presents the spring composition of the Sheep River mule deer herd for the years 1957 to 1959.

Table IV. Herd composition of Sheep River mule deer.

Year	Total	Males		Females		Fawns		Males per 100 females	Fawns per 100 does
		No.	%	No.	%	No.	%		
1957	220	39	18	131	59	50	23	30	38
1958	137	27	20	80	58	30	22	34	38
1959	135	18	13	78	58	39	29	23	50
Three-year figures	492	84	17	289	59	119	24	29	41

Some error may be present in the adult sex ratio. Many bucks are solitary, even in the early spring, and are difficult to census. The true proportion of bucks may be higher than indicated by the figures in Table IV and may be as high as 45 bucks per 100 does.

For Jasper National Park, Cowan (1946) gives figures for the proportion of male mule deer in the adult herd, ranging from 31 percent to 37 percent for the years 1943 to 1946. In a later (1950) paper, Cowan indicates a sex ratio of 53 males per 100 females for mule deer in Banff and Jasper National Parks. In both cases, the areas are protected from hunting and so a larger population of males than that found in the legally hunted Sheep River herd might be expected.

The Sheep River average sex ratio of one buck per 3.4 does (29 males per 100 females) is very close to the average sex ratio of one buck per 3.34 does calculated by Robinette (in Taylor, 1956)

for nine western mule deer states. According to the latter author, sex ratios as low as one buck per fourteen does have been reported with no adverse effect on productivity.

The proportion of does in the herd has remained nearly constant during the years 1957 to 1959. The ratio of rising yearlings to does has fluctuated during the three years, however. A severe winter mortality was noted in the first spring of the study (1957) and fawn survival was only 38 per 100 does. Two mild winters followed. Fawn survival was again low in May of 1958, being only 37 per 100 does. It increased in May of 1959 to 50 fawns per 100 does. Cowan (1950) describes a similar sequence for the deer of Banff and Jasper National Parks beginning with a severe winter in 1942-43 when fawn survival was only 26 per 100 does. The next winter was mild but fawn survival was only 15 per 100 does. Cowan suggested that the fertility of does was lowered by malnutrition in the winter of 1942-43 resulting in a poor fawn crop in the summer of 1944. Thus, it can be seen that a severe winter might diminish two age classes at once. According to Cowan, the 1945 fawn survival then rose to 60 fawns per 100 does, a figure which he thought to be near normal.

In an earlier paper, Cowan (1946) provides fawn survival data for mule deer in the Athabasca Valley of Jasper National Park for the years 1943, 1944, 1945, and 1946. He obtained fawn survival figures of 26, 15, 45, and 33 fawns per 100 does for the respective years. The winter range in the area was badly over-utilized and fawn survival

was much lower than in a normal herd. Two of the figures, however, compare closely with those for the Sheep River herd. Robinette (in Taylor, 1956) states that a fawn survival of 65 to 78 per 100 does is average while a fawn survival of less than 50 fawns per 100 does is subnormal.

From the above examples it can be concluded that the fawn survival in the Sheep River mule deer herd for the years 1957 to 1959 was below normal, in comparison with other areas. Probable reasons for this will be suggested later in the sections dealing with productivity and mortality.

THE RUT

According to Cowan (in Taylor, 1956), the mule deer rut in Jasper National Park occurs from October 24 to November 14. An adult doe which was collected on May 8, 1958, on the Sheep River study area was carrying twin foetuses estimated to be 160 days of age from the foetal descriptions of Armstrong (1950) for white-tailed deer. Assuming a gestation period of 210 days, said to be an average figure for mule deer (Einarsen, in Taylor, 1956), this doe was bred on or about December first, 1957, and would have fawned on June 27, 1958. Another adult doe collected on November 12, 1959, had a well-developed corpus luteum in each ovary but no visible embryos in the uterine horns. According to Cheatum and Morton (1942) a delay of two to three weeks seems to occur between ovulation and implantation in white-tailed deer. It appears likely that a similar delay occurs in mule deer. The number of corpora lutea indicates the number of ova ovulated but is not an indication of the number of embryos since some ova are not fertilized and some embryos die at an early age (Taber and Dasmann, 1957). In Utah, the breeding season reaches a peak from November 20 to December 2 and extends from late October to late January (Robinette and Gashwiler, 1950). This suggests, together with the long fawning period found for Sheep River mule deer, that the breeding season found by Cowan (1944) for Jasper National Park mule deer (October 24 to November 14) may be too short. The peak of the breeding season in the Sheep River herd is estimated to be from November 10 to November 16 and was arrived at by back-dating from the peak of the fawning period in the second week of June.

THE FEMALE CYCLE

1. Breeding

Does normally breed for the first time as yearlings of about eighteen months of age, although some female mule deer fawns six to eight months of age have been known to breed successfully (Robinette et al, 1955). No evidence of breeding by fawns of either sex was found in the Sheep River study.

Apparently, most mature does are successfully bred during the rut (Einarsen, in Taylor, 1956). This is partly because estrous periods recur several times until the doe becomes pregnant and partly because does in heat actively seek bucks.

2. Gestation

Einarsen (in Taylor, 1956) suggests that an average gestation period for mule deer may be considered as 210 days. Robinette and Gashwiler (1950) found an average gestation period of 202 days (range 193 to 209 days) for Utah mule deer. Cowan (in Taylor, 1956), who gives a rutting period of October 24 to November 14, also provides a fawning period of from June 7 to June 14 for the Jasper National Park area. If it is assumed that the middle of each of these two periods represents the peak of activity, the gestation period would

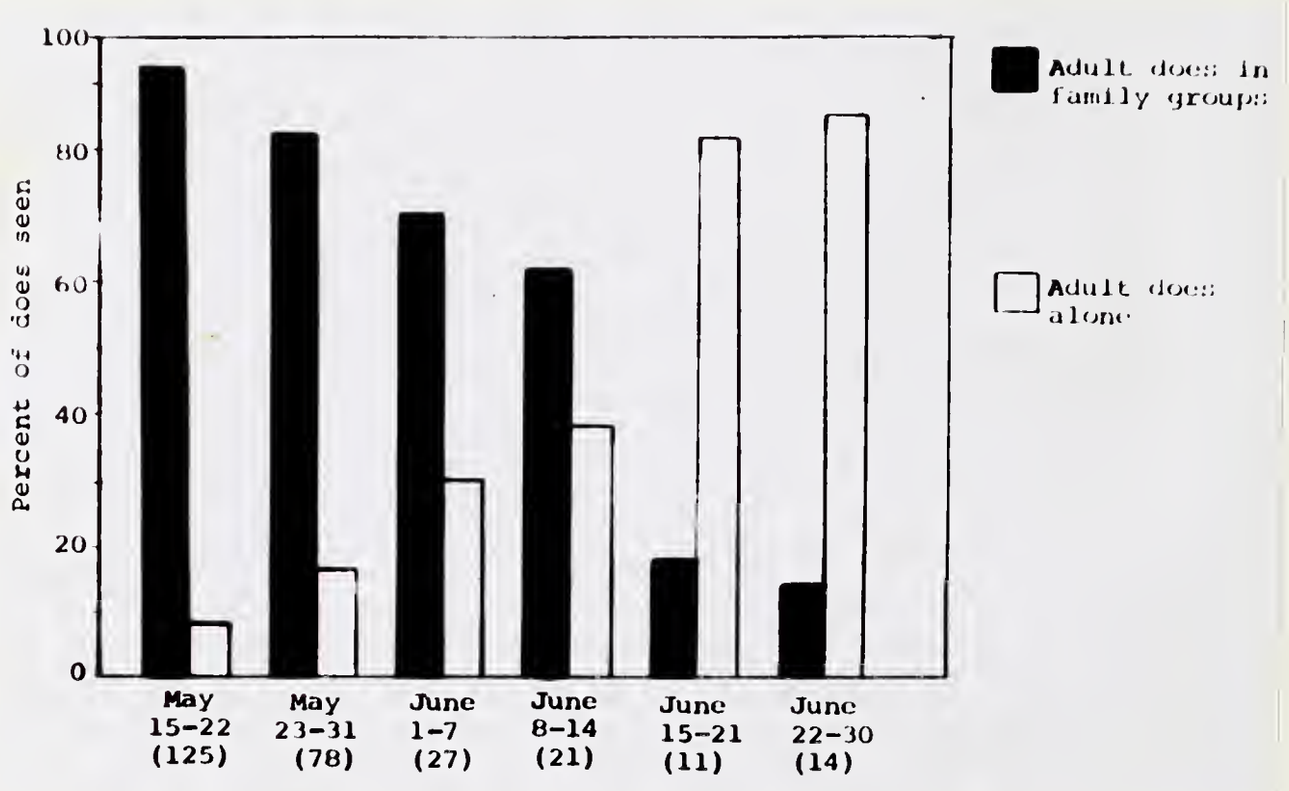


Fig. 9. Adult does in family groups compared with solitary adult does. Total numbers of does seen in each period appear in parentheses.

be 219 days. Two possible explanations are apparent. Either the gestation period of Jasper National Park mule deer is abnormally long when compared with other herds or Cowan's estimates are in error by about one week. No gestation figures were obtained for the Sheep River area.

3. Fawning

As the time of parturition approaches in late May and early June, pregnant does can be seen to isolate themselves from the family groups. At that time, fawns of the previous year are driven away by the aggressive behavior of the does. This type of behavior was seen on several occasions. The appearance of solitary does and decrease in the number of family groups thus serves to indicate the period of fawning. Figure 9 shows the trend in numbers of single does seen compared with numbers of does seen in family groups by weeks during the period of May 15 to June 30 for the years 1957 to 1959. When interpreting the data, it must be borne in mind that solitary does are more secretive and difficult to see than are does in family groups. For this reason, the former are doubtless under-represented.

From the data presented in Figure 9, the peak of the fawning period is estimated to be June 8 to 14. This coincides with Cowan's figure for Jasper National Park of June 7 to 14. Some does in the Sheep River area are known to fawn before this period and some after.

The period of June 8 to 14 also marks the dissolution of nearly all remaining family groups. If a gestation period of 210 days can be assumed, the peak of breeding activity occurs from November 10 to November 16.

Mr. D. A. Boag reported seeing a doe with an enlarged udder on May 27, 1957, to provide the earliest fawning record for the Sheep River area. Marked doe number 66 was still believed pregnant when recaptured on June 21, 1959. A doe collected on May 8, 1958, with twin foetuses estimated to be 160 days of age would have fawned about June 27, 1958. The fawning period of Sheep River mule deer is spread over at least a month and may actually cover a period of five weeks.

GROWTH AND DEVELOPMENT OF FAWNS

1. Foetal Development

An adult doe collected May 8, 1958, contained two female foetuses whose measurements appear in Table V. They were estimated to have been about 160 days old from foetal descriptions for white-tailed deer given by Armstrong (1950). Two foetuses collected on the study area in May of 1956 by Mr. W. D. Wishart weighed a total of 9 pounds, but the foetal membranes and the uterus were included. The above examples represent the only data obtained on foetal development.

Table V. Data on the twin foetuses collected May 8, 1958

Sex	Female	Female
Total weight	4 lb.	4 lb.
Total length	$18\frac{3}{4}$ in.	$20\frac{3}{4}$ in.
Length of hind foot	$6\frac{1}{4}$ in.	$6\frac{1}{4}$ in.
Ear from notch	$2\frac{3}{4}$ in.	$2\frac{3}{4}$ in.
Length of metatarsal gland	$1\frac{3}{4}$ in.	$1\frac{3}{4}$ in.
Length of tail	$1\frac{3}{4}$ in.	2 in.
Crown-rump length	$13\frac{3}{4}$ in.	-

2. Sex Ratio of Fawns

Sex ratios of mule deer foetuses and fawns in other areas have shown a preponderance of males over females. Robinette et al (1955)

found a foetal sex ratio of 111 males to 100 females for mule deer in Utah. In a summary of earlier literature, Taber (1953) gives a sex ratio of 122 males to 100 females for Rocky Mountain mule deer fawns at birth. No significant information regarding fawn sex ratios was obtained for Sheep River mule deer.

3. Travel

During the first month of life, fawns travel very little. Does having fawns move to feeding areas unaccompanied, leaving their young in dense cover until they return. Fawns are seldom seen during that period which lasts until mid-July. As the fawns become older and stronger and begin to feed more on vegetation, they often accompany their mothers and are then seen more frequently. By late August, does with fawns are seldom seen alone. Table VI compares the number of does with the number of fawns seen by months for the combined years 1957 to 1959. Yearlings are included with adult does except in the May sample where they are excluded entirely. Deer which are 11 months of age in May are here considered to be yearlings as opposed to young of the current year .

Table VI. Number of does and fawns sighted by months, 1957 to 1959.

Month	May	June	July	August	September *
Does	362	78	55	59	12
Fawns	0	6	7	35	9
Fawns per 100 does	0	8	13	59	75

* Only the first half of September was spent on the study area.

Einarsen (in Taylor, 1956) points out that fawns are easily overlooked when making fall counts. Fawns are undoubtedly under-represented in Table VI, even in the August and September records. A striking example of the ease with which fawns can be overlooked occurred on July 20, 1958. While travelling with a companion on a winding trail in the vicinity of Dyson Creek, I came suddenly on an adult buck and an adult doe with a large udder. The two deer watched us intently for several minutes before moving into the dense lodgepole pine cover beside the trail. Fresh tracks in the mud of the trail indicated that two fawns had been accompanying the adult deer before our arrival. They had perhaps heard us and taken cover while the doe and the buck remained in the open to investigate the disturbance. A hurried search of the surrounding vegetation revealed no trace of the fawns. Such shyness on the part of fawns may be quite common, making accurate counts impossible.

4. Fawn Pelage

Mule deer fawns are born with the red dorsal pelage marked by six rows of white spots which are apparent for eight to ten weeks after birth. As the hairs grow, the tips break off and the spots finally disappear (Cowan, in Taylor, 1956). Fawns without spots were seen as early as the first week in August. No spotted fawns were seen after August 27 during the three years of the study. The disappearance of the spots from the pelage of fawns coincides with their increased propensity to accompany the does in their daily wanderings. In Oregon, a few spotted fawns were seen as late as September first (Einarsen, in Taylor, 1956).

5. Weaning

According to Einarsen (op. cit.), nursing of mule deer fawns is lessened by the age of three months and weaning is complete by the end of five months. Twelve mule deer fawns raised by Cowan et al (1957) were weaned at 47 to 68 days of age. In the Sheep River area nursing begins to decline in late August as evidenced by a gradual decrease in the udder size of most does. Hunting returns from mid November, 1959, indicated that many does are still lactating at that time of year (five months after fawning), though lactation volumes are reduced considerably.

6. Growth

No weights and measurements were obtained from fawns in early

Fig. 10. Antler condition of a buck at one and one-half years of age.

Photo by Morley Riske.

life. However, a female fawn collected on May 14, 1958, at an age of 10 to 11 months had a total weight of 74 pounds and the following measurements: total length--56½ inches, tail--7¼ inches, ear--8 inches, hind foot--18 inches, and metatarsal gland--5 inches.

7. Antler Development with Age

Many male fawns develop short antlers one half to one inch in length by their first winter. The velvet is shed from these before mid November. These first antlers are rarely visible, except at very close range, being covered almost entirely by the surrounding hair. The typical yearling antler has one small fork (Fig. 10), but a few yearlings were seen with simple spike antlers. The appearance of spike antlers on yearling mule deer bucks is considered to be a sign of poor nutrition in some areas (Einarsen, in Taylor, 1956). Two-year-old bucks generally have antlers with three points each (Frontispiece), but some have antlers with only a single fork, although larger than those of yearlings. Three-year-olds also commonly have three-pointed antlers but exceptionally vigorous animals may develop four points. The typical four-pointed antler is normally developed by the fourth or fifth year and is the common antler type during the life of the mature buck.

PRODUCTIVITY

As pointed out previously, fawn counts taken in late summer and early fall are unreliable because of the difficulty of observing fawns and because, while most fawns accompany does by late August, some do not. In addition, it was found to be impossible to distinguish between adult and yearling does in late summer with any reasonable degree of accuracy. In California, Dasmann and Taber (1956 b) were able to separate adult and yearling Columbian black-tailed deer in the fall on the basis of size and behavior differences. This might be applied to mule deer if an observer had sufficient experience. It is often possible to distinguish yearling from adult does if they are together but single does are difficult to age. Small adults and large yearlings present further complications. It was not found possible to separate these two age classes of Sheep River mule deer in late summer.

Table VII summarizes the numbers of fawns seen accompanying does for the summers of 1957, 1958, and 1959. The percentage of does with single fawns was lowest in 1957 following a winter of high mortality. This was contrary to expectation and a satisfactory explanation is not readily apparent. The sample included only eight does and may have been too small to be significant. According to Cheatum and Severinghaus (1950) low nutrition levels tend to lower productivity by increasing prenatal mortality and by lowering lactation volumes of does. Thus, it might be expected that the

number of twin fawns would be lower in 1957 than in the other two years, when winter mortality was less. Table VII excludes does without fawns.

Table VII. Fawns accompanying does, 1957 to 1959.

Year	Number of does	Fawns per doe	Does with single fawns
1957	8	1.6	38%
1958	15	1.3	73%
1959	18	1.5	44%
Three-year composition figures	41	1.4	54%

The ratio of fawns to total does seen from August 8 to September 8 for the years 1957 to 1959 is considered in Table VIII. By taking the ratio of yearlings to adult does determined in May of each year and assuming a yearling sex ratio of one male to one female, an estimate of the number of yearling does seen in late summer can be made. However, it is highly probable that yearling does are more readily seen than adult does with fawns. Thus, the population of yearlings seen in late summer may actually be higher than the estimate.

Table VIII. Productivity of Sheep River mule deer, 1957 to 1959 (August 8 to September 8).

Year	Female fawns per 100 does in May	Total does seen	Total fawns seen	Number of does with fawns	Estimated number of yearlings in sample	Estimated number of adult does in sample	Adult does without fawns		Productivity-Number of fawns per adult doe
							No.	%	
1957	16	19	9	7	3	16	9	56	0.6
1958	16	21	13	12	3	18	6	33	0.7
1959	20	11	9	5	2	9	4	44	1.0
Three-year composite	17	51	31	24	8	43	19	44	0.7

Although the productivity figures are not absolute, they do indicate a trend which fits in nicely with winter mortality figures for the three years (see Table XIX). Productivity was probably highest in 1959, the year of lowest winter mortality, and lowest in 1957, the year of highest winter mortality. Actual productivity is believed to be one-quarter to one-third higher than the figures in the last column indicate, if allowance is made for fawns present but not accompanying does.

THE MALE REPRODUCTIVE CYCLE

1. Breeding

A visit was made to the study area from November 11 to 14, 1959, the period of the first either sex mule deer season in many years in the Sheep River area. This should also have coincided with the peak of rutting activity but I saw no adult bucks and hunters took only one $2\frac{1}{2}$ year old in that class. The buck season had been open for some time prior to the opening of the doe season. There is a possible explanation of the apparent scarcity of adult bucks during a period of the year when they should have been most active. While studying the behavior of Columbian black-tailed deer, Dasmann and Taber (1956 a) noticed that, shortly after the hunting season opened, experienced adult bucks restricted their daytime activities to small patches of dense cover. Only at night would the mature males seek out the does, thus avoiding encounters with hunters.

2. Antler Development

Dasmann and Taber (1956 a) found that most adult Columbian black-tailed bucks shed their antlers within a period of one week. Yearlings lost their antlers about two weeks later than adults. According to Einarsen (in Taylor, 1956), mule deer in Alberta shed their antlers from February until April 15. Scarcely any antler growth takes place before May first in Sheep River mule deer. If the antlers are shed as early as February, there must be a period

Figure 11. Antler development of adult buck collected on July 19, 1959.

Figure 12. Antler of a large adult buck as seen on July 19, 1959. Antler is not from the same animal as that shown in Figure 11.

of up to $2\frac{1}{2}$ months when no growth takes place. Antler growth begins with the higher nutrition levels provided by spring vegetation. Figure 13 illustrates the average rate of antler growth during the summer months. The graph is based partly on visual estimates at close range and partly on actual measurements of specimens collected and killed by hunters. The typical adult mule deer antler, when fully developed, has four points excluding the brow tine which may or may not be present. Prime adult males often have antlers bearing accessory points. Other antler irregularities may result in cases of injury or old age (Cowan, in Taylor, 1956).

In early May, the antlers of adult bucks are one-half to one inch in length (Fig. 34). The primary fork appears during the first two weeks of June while the two secondary forks appear by the third week in July (Figs. 11 and 12). The antlers of yearlings are slower to commence growth in the spring. A period of more rapid growth is apparent in adult antlers during the latter part of June and early part of July (Fig. 13). Bucks are in good condition by that time which seems to be reflected by increased antler growth. By late August the antlers are covered by a dense, light-brown fur except at the tips (Frontispiece). A buck which had just stripped the velvet was seen on September 9, 1957 at an elevation of 6,500 feet. This was the only buck without velvet seen during the summer portions of the study. An adult buck collected on September 4, 1958, had antlers which were still growing at the tips. Probably most bucks are out of the velvet by the middle of October.

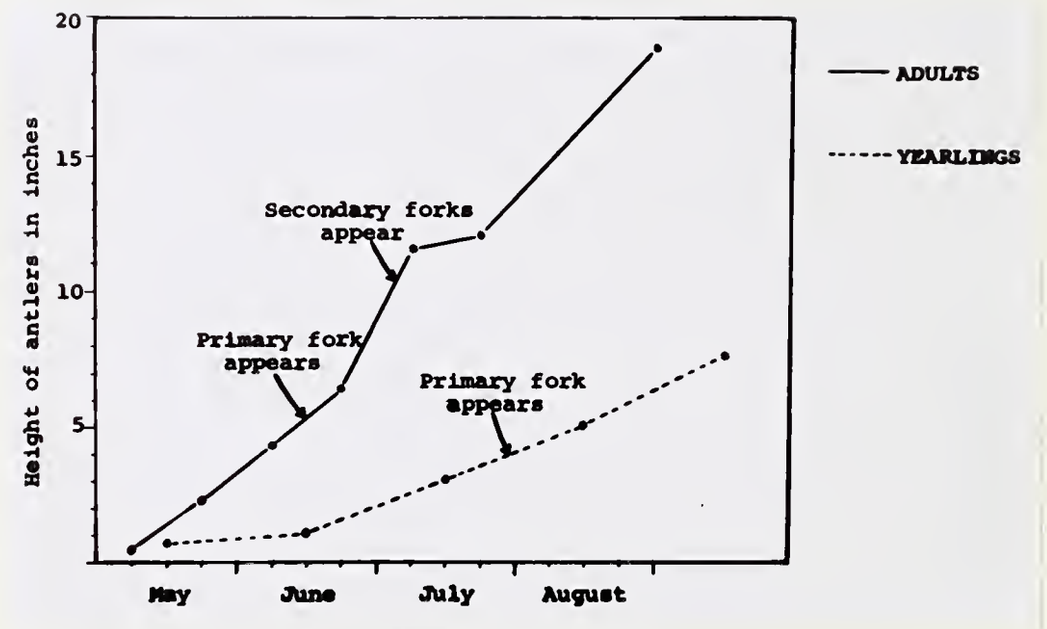


Fig. 13. Antler growth of Sheep River mule deer bucks based largely on sight records.

3. Testes Changes

Two testis samples were collected during the summer of 1959. They were fixed in Bouin's fixative and stained with Ehrlich's haematoxylin. The first sample was from an adult buck shot July 19, 1959. A few mature spermatozoa were present in the seminiferous tubules but most of the cells were in the primary spermatocyte stage. The second specimen was from a two and one-half year old buck shot on August 26, 1959. In this case, the testis was in nearly the same condition as that taken from the earlier buck except that a few more spermatozoa were present in the tubules. Neither buck was in breeding condition.

SIZE, COMPOSITION, AND DESCRIPTION OF MULE DEER GROUPS

During the study, deer group size was found to be greatest in May when large, fluctuating spring feeding associations were encountered. The size of deer groups decreased in early June when yearlings were rejected by the adult does approaching parturition. Group size was least in late June and early July when adult does were travelling without their fawns and yearlings had not yet won reacceptance to the family groups. During August and September group size increased as family groups of does, yearlings, and fawns were re-formed. Table IX shows the size of the deer groups seen by months during the three summers.

Table IX. Deer group size by months

	Number of groups seen											
Group size	1	2	3	4	5	6	7	8 to 10	11 to 15	16 to 24	Total number of groups	Average group size
May	112	115	72	67	47	30	23	39	31	9	545	4.03
June	69	38	13	2	3	1					126	1.69
July	83	14	5	3	1						106	1.35
August	49	17	8	2	2						79	1.68
September	7	7	3				1				18	2.06

The composition of deer groups is presented in Table X. The study period is here divided into three periods: May 1 to June 15, characterized by family groups and feeding associations; June 16 to August 15, a period when many deer are solitary; and August 16 to September 15 when most family groups are re-formed.

Table X. Composition of Sheep River mule deer groups from May 1 to September 15.

Composition of group	May 1 to June 15		June 16 to August 15		August 16 to September 15	
	frequency	%	frequency	%	frequency	%
adult female alone	50	21.3	83	56.5	16	31.4
2 adult females	20	8.5	2	1.4	2	3.9
more than 2 adult females	8	3.4	0	0	1	20
adult female + fawn*(s)	24	10.2	15	10.2	13	25.4
2 or more adult females + fawn*(s)	27	11.4	2	1.4	2	3.9
fawn*(s) alone	14	5.8	2	1.4	0	0
adult female + fawn(s)* + adult male(s)	41	17.4	1	0.7	1	2.0
adult male + adult female	4	1.7	2	1.4	0	0
adult males + adult females	8	3.4	0	0	0	0
adult male alone	21	8.9	26	17.6	10	19.6
more than 2 adult males	5	2.1	5	3.3	1	2.0
2 adult males	14	5.9	9	6.1	5	9.8
Totals	236	100	147	100	51	100

*In the period from May 1 to June 15 mule deer of 10 to 11 months of age are designated as fawns but in the later periods (after June 15) they are counted as adults.

As can be seen from Table X, male mule deer seldom associate with does from June through September. Many bucks spend the summer alone, while others form small groups composed exclusively of their own sex. Table XI presents data which show the variation in size of these buck groups. The largest buck group seen during the course of the study included five bucks. The average size of buck groups was found to be 1.57.

Table XI. Size of buck groups, 1957 to 1959.

size of group	1	2	3	4	5
frequency	57	28	7	3	1
%	60	29	7	3	1

Although the spring feeding associations often result in large groups of up to 20 animals, it is believed that the family and buck groups retain their identities within the larger and more loosely organized groups. This has been established for Columbian black-tailed deer by Dasmann and Taber (1956 a).

By the third week in May, large feeding associations are seldom seen because a greater feeding area has become available. The mule deer disperse in smaller family units which are soon broken up when the adult does seek seclusion at the approach of the fawning period. Very few family groups are seen by the second week in June. Many yearling males join buck groups at that time while most yearling

females live a solitary life for about six weeks. When the new fawns begin to travel in early August, the yearling does again join the family groups and are once more tolerated by the adult does. Yearling bucks seldom rejoin the family groups, although a few exceptions were noted during the study. Buck groups probably break up with the onset of rutting activity in October (Dasmann and Taber, 1956 a).

SEASONAL MOVEMENTS

Winter

Sheep River mule deer do not appear to be migratory but some winter movement to areas where snow depth is less, such as the tops of ridges, seems likely. Alberta Government Biologist Mr. George Mitchell, who flew over the study area as part of a census in the winter of 1958-59, spotted a small group of mule deer near Junction Lookout (Fig. 1) at an elevation of about 7,200 feet. That some deer winter at this elevation is further established by the number of shed antlers picked up in the area. Antlers are probably shed in February and March during the winter period. Reports of mule deer seen during the winter at the Sheep Ranger Station indicate that mule deer in the area winter in small scattered groups whose movements are rather restricted. The chief wintering group is probably the family unit which, according to Einarsen (in Taylor, 1956), is formed once again following the rut. Shed antlers which were picked up during the course of the study have been plotted on Figure one. Antlers were found in all habitats, suggesting a scattered winter range which may, in fact, be nearly the same as the summer range.

Spring

Beginning in late March (according to information supplied by the staff of the Sheep Ranger Station) the mule deer congregate on

Fig. 14. Typical spring feeding habitat just above the Alberta Biological Station.

Fig. 15. Marked doe number 67 showing type of tags used.

Photo by Peter Hochachka

the open southwest slopes where the snow has melted. By the time the grass begins to grow in mid-April, most of the deer in the study area can be seen in such situations (Fig. 14). This might be considered a type of migration. The distance which deer travel to reach spring feeding sites is unknown but may be several miles in some cases.

Four deer were trapped and tagged during the course of the study and, although they provided little information on summer movements, they did furnish some interesting information on spring activities. Table XII summarizes the trapping and tagging information for the four animals. In addition, an adult doe recognized by a large swelling on the outside of the left ankle joint is included.

The male fawn tagged on August 15, 1957, was thought to have been seen on May 19, 1958, but had lost his tag. A gash in the right ear marked where the tag had been. Doe number 67 was tagged on June 10, 1959, and was never seen again. Colored plastic strips were specially cut as markers so that they could be tied through the ear with a falconer's jess knot. This method proved very satisfactory and no markers were known to have been lost. Another type of marker in the form of a plastic disc was used and was attached by means of a button ear tag. A marker of the latter type was believed to have been lost by fawn number 62. All tagged animals were marked with numbered aluminum button ear tags supplied by the Alberta Game Branch (Fig. 15).

The three tagged does were captured in a corral trap baited with

salt. The male fawn was captured in a snare of the type developed by Ashcraft and Reese (1957). The trigger used by Ashcraft and Reese was adapted to the corral trap and worked satisfactorily. Attempts at using tranquilizers such as nicotine salicylate (Crockford et al, 1957) to capture mule deer were unsuccessful.

Table XII summarizes the observations made on the marked deer. All observations, except those of the naturally marked doe, were made in the spring as late as June 21. The doe with the swollen left ankle was first seen in August, 1958, at the stock lick at the Sheep Ranger Station. By May, 1959, she had moved a distance of 2,300 yards to a different area. Unfortunately, no marked deer were seen on their summer home ranges, although doe number 65 may have been close to her home territory when seen by Mr. D. A. Boag in June, 1960, near the top of Missing Link Mountain.

Table XII. Observations of tagged mule deer

Date tagged	Date last seen	number	Sex	Age	Number of observations after marking	Least distance from point of marking (yards)	Greatest distance from point of marking (yards)	Greatest distance between observations (yards)
Aug. 15/57	May 19/58	62	male	2 months	1 (?)	150	150	150
May 27/58	May 12/59	swollen ankle	female	adult	3	0	2,300	2,300
Aug. 16/58	June, 1960	65	female	15 months	12	0	1,000	1,600
June 2/59	May 21/60	66	female	adult	5	0	600	800
June 10/59	June 10/59	67	female	adult	0	-	-	-

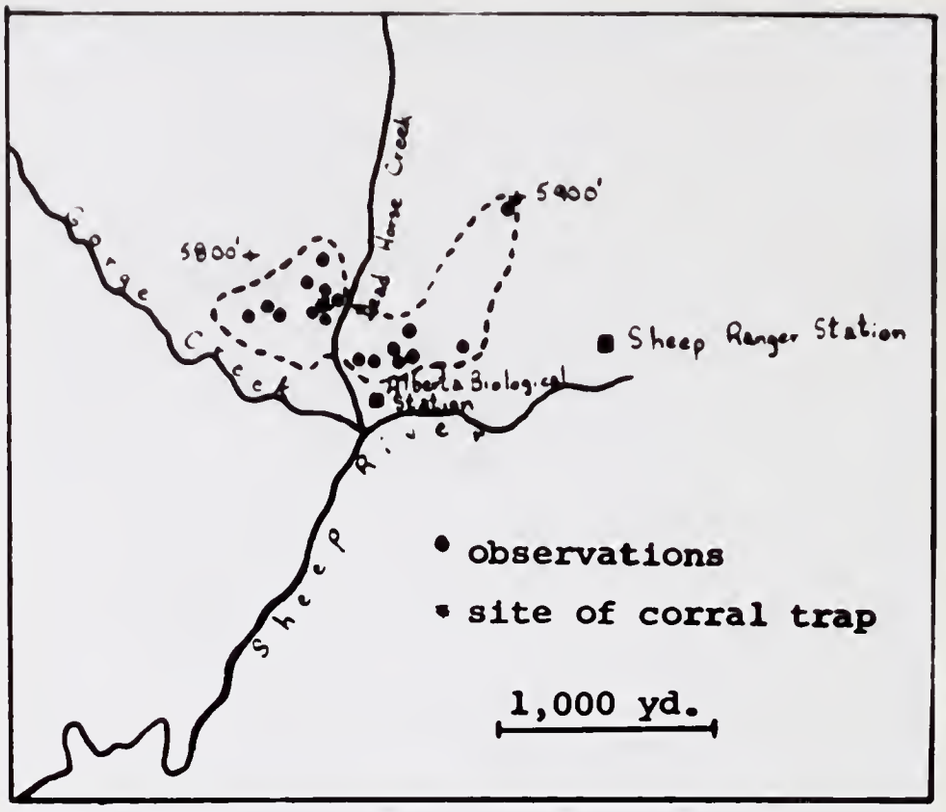


Fig. 16. Spring range of tagged doe number 65.

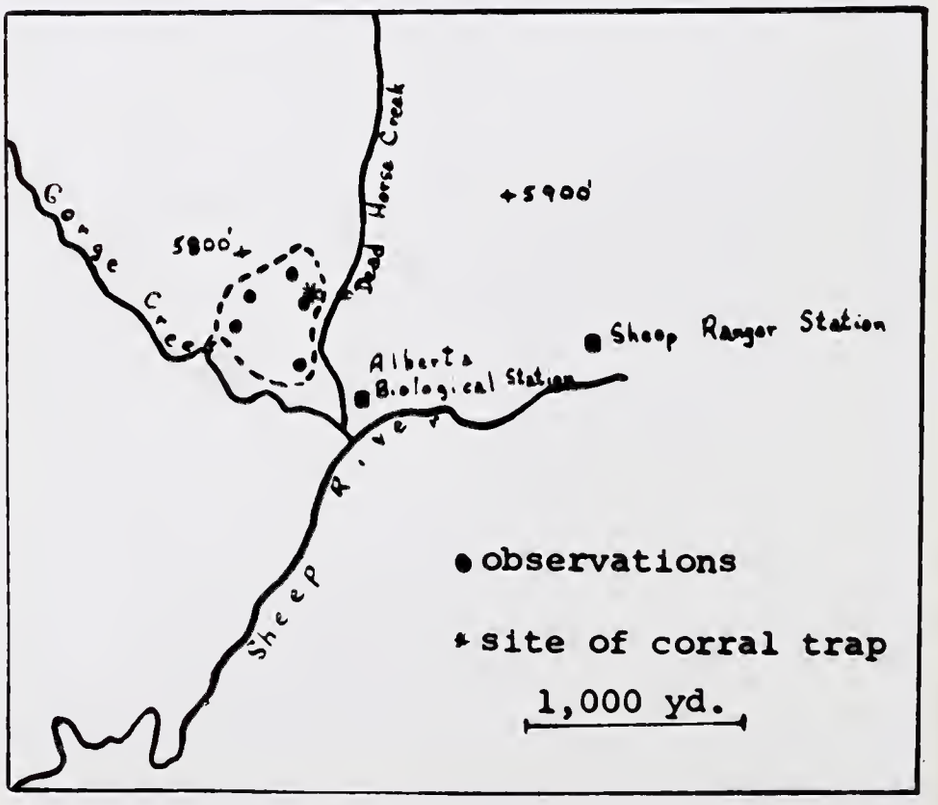


Fig. 17. Spring range of tagged doe number 66.

The spring ranges of marked does 65 and 66 and the adult doe with the swollen left ankle are shown in Figures 16, 17, and 18, respectively. Most of the observations were obtained on open slopes and in clearings where visibility was good. Tagged does 65 and 66 used the same spring range for two successive years. This indicates that the spring population estimates may be quite accurate since little movement seems to occur between distinct spring feeding areas. The doe with the swollen ankle, however, seemed to change her spring range in 1959.

Summer

Following the spring dispersal, most does remain at lower elevations where they have their fawns and spend the summer. Some bucks, yearlings, and barren does may move to higher elevations at that time of year, but insufficient evidence is available to confirm this. On the other hand, it may be that these deer are actually resident at higher elevations throughout the year. No fawns were seen at extremely high elevations (over 6,800 feet), but some were seen just below timberline. Buck groups are often seen in open alpine meadows during the summer.

Fall

As early as September, restlessness on the part of bucks was noted in the Sheep River area. At that time of year, bucks that had not been seen all summer suddenly appeared on closely observed portions of the study area. This increased travel on the part of bucks may be a result of increasing sex hormone levels which signify the approach of the rut. No unusual movements were noted among other deer during the period of early fall.

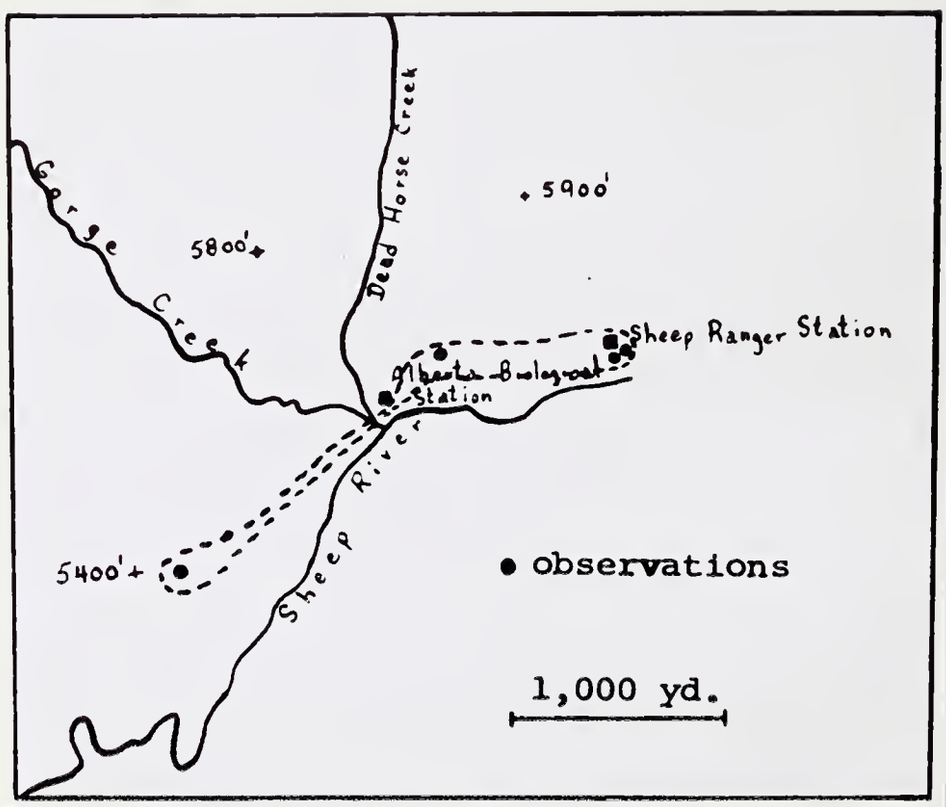


Fig. 18. Spring range of doe recognized by swelling on left ankle.

DAILY ACTIVITY

Daily activities of Sheep River mule deer vary seasonally and according to the weather. The period from May 1 to September 15 can be conveniently divided into two distinct periods. The first of these includes the months of May and June when spring feeding is at a maximum. The second may be termed the summer period from July 1 to September 15. Figures 19, 20, 21, and 22 present data which show the daily activity patterns between these two periods. In these figures the spring and summer periods are sub-divided into three times of day: morning, mid-day, and evening. Percentages have been worked out on this basis for both the spring and summer periods.

Bedding

In the spring, bedding is most common during the late morning and early afternoon but is usually interrupted by short periods of feeding. At this time of year, mule deer in early morning and late evening feed for short periods of up to an hour in length, lie down

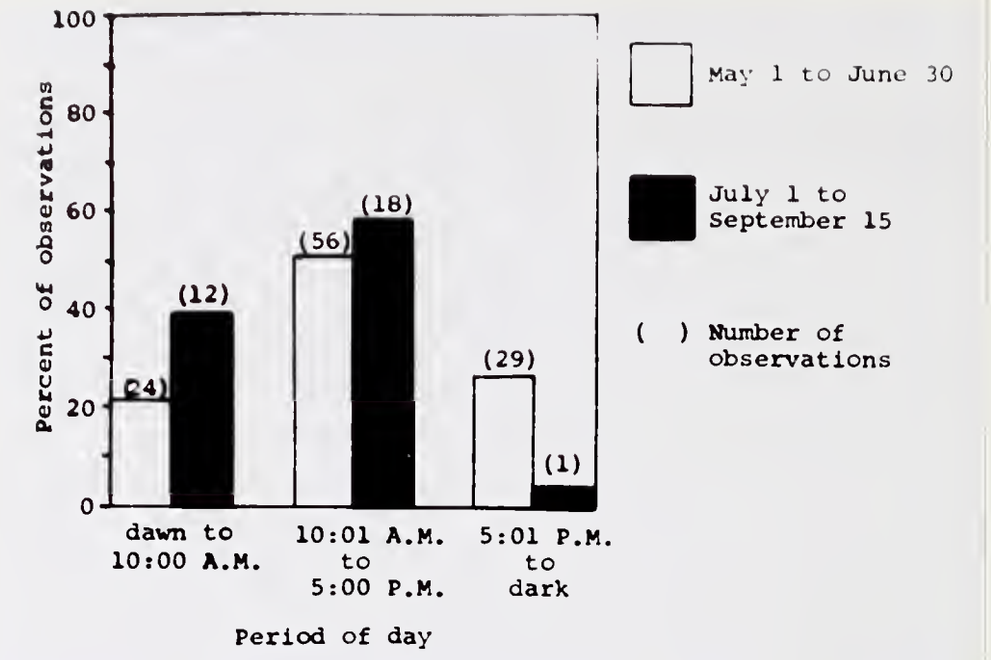


Fig. 19. Comparison of spring and summer bedding activity.

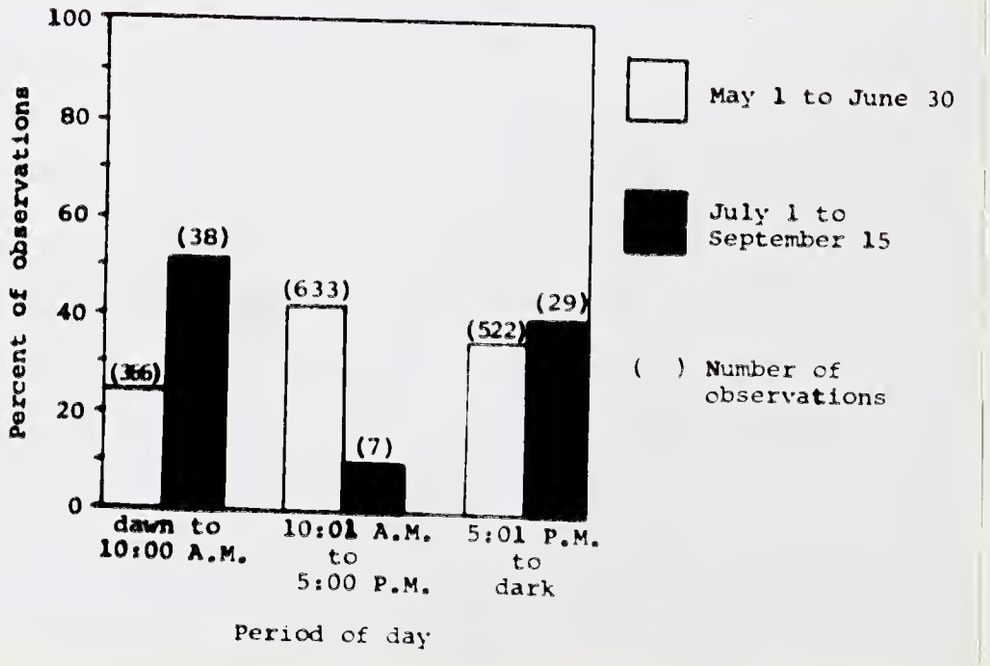


Fig. 20. Comparison of spring and summer feeding activity.

and chew the cud for periods of about half an hour, then arise and begin to feed once again. Spring beds are often in open cover and even in places which provide no cover at all. During the summer most of the mid-day period is spent in a bed in dense cover. Deer are rarely seen moving about in the middle of the day at this time of year.

Feeding

In the spring feeding is the major activity of Sheep River mule deer and the latter may be seen in the open at any time of day. The periods of most intensive feeding are morning and evening, however. In contrast, during the summer period, feeding animals are rarely encountered in the middle of the day (see Fig. 20). Feeding is largely confined to early morning and late evening and probably extends into the night as well.

Travelling

Travelling is minimal during the spring period since most deer spend their day in close proximity to the feeding area. In summer, mule deer are often seen from 6:00 A.M. to 7:00 A.M. as they travel from feeding areas to their beds (see Fig.22). Travelling in the evening is less obvious because the deer begin to feed as soon as they leave their beds and wander slowly away. Feeding probably begins in the same way in the morning but it commences in the dark. Mule

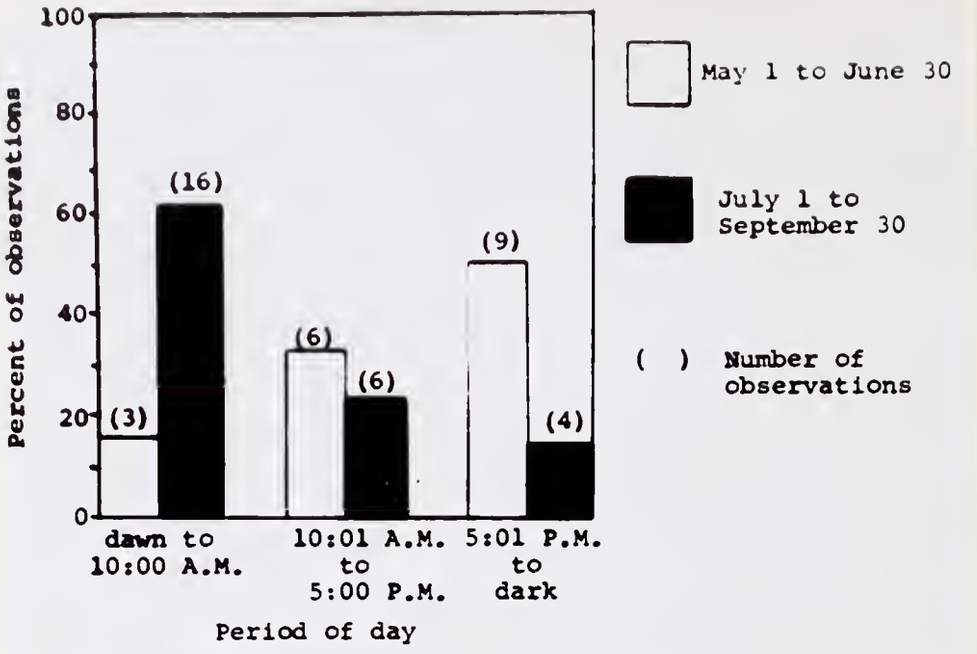


Fig. 21. Comparison of spring and summer travelling activity.

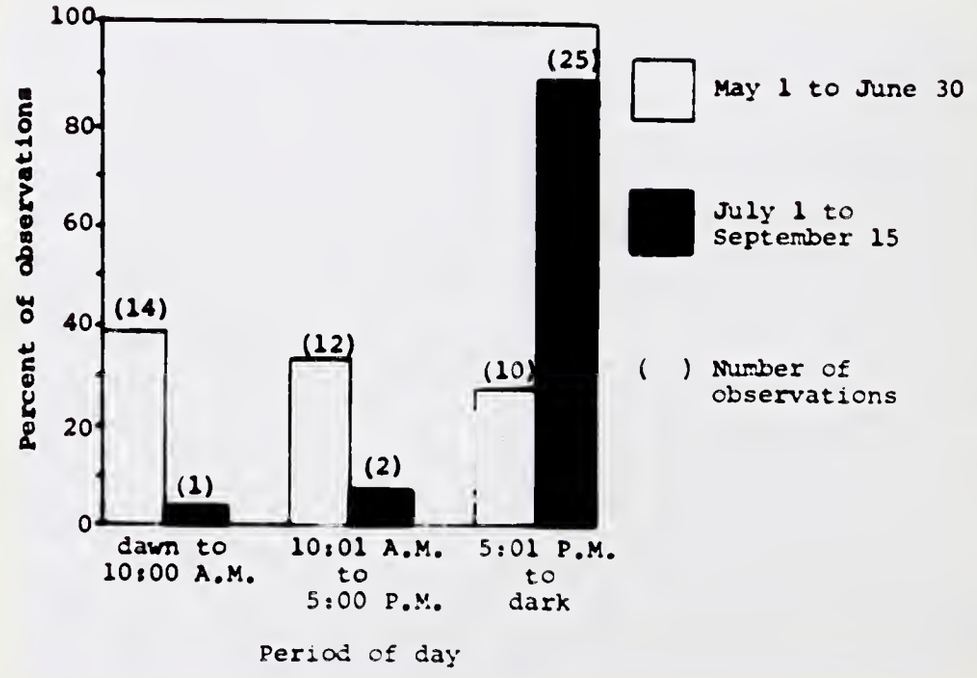


Fig. 22. Comparison of spring and summer salting activity.

deer that are travelling to day beds do so in a determined manner, seldom stopping to feed.

Carlsen and Farmes (1957) found that yearling white-tailed deer travelled farther than adults on the average. This was not believed to be the case with the Columbian black-tailed deer studied by Dasmann and Taber (1956 a). No conclusive evidence indicating greater travel on the part of yearlings was found for the Sheep River area. Yearlings expecting to rejoin family groups might be expected to remain close to the home ranges of their mothers.

Salting

Another reason for travelling is for the purpose of utilizing salt licks. One deer was known to have travelled two miles to a lick and to have returned to its starting place in the same night. Such travels are largely confined to the morning and evening periods during the summer. In the spring, however, mule deer approach salt licks at any time of the day. Morning licking observations are under-represented in Figure 22, but during the summer the greatest salting activity probably does occur in the evening, as the graph shows.

Drinking

Mule deer were not observed drinking by the writer during the course of the study. However, Mr. Edgar Allin reported having seen three bucks drinking from Gorge Creek in the middle of the hot afternoon

of August 22, 1958. Most deer probably require water, particularly in summer (Browman and Hudson, 1957).

Home Range

No definite evidence that mule deer possess well-defined summer home ranges was revealed in the Sheep River study but it seems likely that does with fawns probably do have definite home ranges. If mule deer in the Sheep River area are comparable to the Columbian black-tailed deer studied by Dasmann and Taber (1956 a), they spend most of their time on home ranges having definite boundaries. Sheep River mule deer commonly leave their home areas to visit salt licks. Many adult bucks do not seem to be restricted to a home range, as several were known to have spent a few weeks in one place and then to have disappeared, apparently to another area.

The Effect of Weather on Mule Deer Activity

Cold, wet weather confines mule deer to heavy cover but when the precipitation stops, deer are inclined to seek food. At such times they often travel on roads and wide trails away from wet vegetation. On hot days, mule deer are inclined to bed earlier in the morning and arise later in the evening than usual. Observations and track records indicate that salting activity is greater during hot weather than during cool, wet weather. Deer were known to have visited licks in rainy weather on only two occasions. Wind restricts

mule deer activity, possibly because their sense of hearing is greatly limited on windy days. Such days are spent in sheltered situations. When a strong wind is blowing, it is often possible to approach mule deer closely.

BEHAVIORAL NOTES

Individual Behavior

1. Sensory perception

Hearing in mule deer is very acute and is the chief means of detecting the presence of other animals in their environment (Linsdale and Tomich, 1953). Sound alone is not usually enough to cause flight, however. Upon hearing some disturbance, mule deer will, in most cases, attempt to discover the cause. Eyesight is quite poor in mule deer and, while moving objects are easily detected, stationary ones are usually overlooked, except at very close range. Thus, it is this insistence that noises be identified visually, that makes mule deer relatively easy to shoot.

If the hunter remains out of sight, the deer will stand in confusion, even though several shots are fired. Even when one of a group is shot, the others may not flee until the hunter reveals himself.

Mule deer seem to have a good sense of smell, but its dependence on air currents to carry the stimulus makes it rather unreliable as a means of detecting danger. Most hunters realize the value of approaching deer from "downwind". On one occasion, a deer was seen to follow the trail of another by smell, although it had no previous knowledge of the presence of the other deer. Presumably, the tarsal, metatarsal, and interdigital glands secrete odorous substances which

advertise the presence of an individual to others of its kind (Browman and Hudson, 1957). On several occasions, deer of both sexes were seen to urinate on the tarsal glands and rub them together. According to Severinghaus and Cheatum (in Taylor, 1956), white-tailed does encourage this behaviorism in their fawns at an early age.

2. Investigative Behavior

Mule deer are curious animals and will investigate most disturbances unless badly startled. On catching sight of something, they will walk to within 50 feet of the object to get a closer look, sometimes trying to maneuver to the downwind side to aid in identification. For example, on the morning of May 19, 1958, two 11-month-old fawns were surprised while feeding. They did not recognize the observer immediately, although only 40 feet away, but moved forward a few steps and gazed intently for 15 minutes before retreating. This investigative behavior may occasionally be advantageous to mule deer predators.

3. Secretive Behavior

On several occasions mule deer were seen bedded down but were ignored until they had been passed. The deer remained motionless as long as they were hidden, but once they had been seen, they flushed immediately. According to Dasmann and Taber (1956 a) Columbian black-tailed bucks are very difficult to flush during the hunting season. Since a similar behavioral trait exists in mule deer, it probably enables them successfully to avoid hunters also.

4. Irritability

At times during the study, deer were noted to be highly nervous. The least noise, whether significant or not, was apt to put them to flight. Most such instances occurred following a rain when the air was calm and the ground wet. It is suggested that erratic flights of this nature may be caused by the muffling effect of the wet ground which induces a greater degree of alertness and sensitivity on the part of the mule deer. Changing humidity levels following showers have been shown to cause increased olfactory irritability in red deer (Darling, 1937). This may explain the observed irritability of Sheep River mule deer. Dasmann and Taber (1956 a) noted a similar irritability in black-tailed deer and suggested that it might be caused by high population densities and lower nutrition. They also found that poor nutrition reduced the amount of play activity. No incidence of play was encountered during the Sheep River mule deer study.

5. Cooling

On hot days, mule deer were often seen walking with their mouths open. This may aid in cooling the animals by increasing evaporation.

Group Behavior

1. Contagious Behavior

Contagious behavior constitutes the principal alarm mechanism of the mule deer group. Two warning mechanisms were noticed. The first of these was the alert posture with head and ears erect. This was often sufficient to arouse the entire group to alertness. The second is the snort caused by air forcibly exhaled through the nostrils and is usually followed immediately by flight. The snort, although it serves as a warning to the group, is emitted by solitary deer as well. The flight of one member will usually cause the whole group to follow.

Feeding and bedding seem to be examples of contagious behavior. If one deer in the group arises from a bed to feed, the others will shortly follow. Such behavior probably depends on the age and status of the initiator. Young deer might be ignored in such situations if their actions were contrary to those of the older group members.

2. Dominance

Einarsen (in Taylor, 1956) states that mule deer family groups are led by adult does and buck groups by older bucks. Such seems to be the case with Sheep River mule deer. However, one exceptional group of four adult does, encountered on several occasions in May of 1958, was led by an adult buck. The buck preceded the group in flight

and to and from the bedding areas. When the group bedded on an open slope, the buck assumed a position above the rest of the group.

Browman and Hudson (1957) describe dominance orders for penned mule deer. There appeared to be dominance orders in Sheep River mule deer but without tagged animals it was impossible to define them. Aggressive acts were noted on the feeding areas in spring but were most common at salt licks. No actual contact was ever observed but threats were common and usually involved a lunge and a thrust with one of the forefeet. In some cases, one or both contestants would rear up on the hindlegs and spar with the forefeet. Sometimes a toss of the head served as a threat.

Differences in tolerance between individuals were noted. Some dominant deer allowed others to enter the lick area (most of which had several salting sites), while others were more aggressive and drove all lesser deer away. Some deer were driven away repeatedly before they finally left. From the observations obtained, most adult bucks seem to be dominant over does. Both achieve dominance over yearlings and fawns.

3. Familial Behavior

Familial behavior, as used here, involves relationships between an adult doe and her offspring. On several occasions does were seen to lick their fawns about the head and neck.

The fawns usually responded by nuzzling the does in the neck region.

The voice of the doe was heard on only two occasions. It consists of a series of short, low-pitched bleats, audible to the human ear for up to 150 yards. The call apparently serves to summon the fawn. On one occasion it was given by an adult doe in a group of deer travelling through trees. The second occasion was an unusual one. A female fawn was accidentally killed by an overdose of tranquilizer on May 14, 1958. The four remaining deer in the group fled, but after a few minutes an adult doe returned and called quite loudly. She saw me bending over the fawn and lay down to watch at a distance of 100 feet. The fawn was carried to the Biological Station, a distance of about 400 yards. Three hours had passed when the adult doe suddenly appeared 150 yards from the buildings, calling loudly.

On another occasion, when tagged fawn number 62 was captured at two months of age, the accompanying doe waited near by until her fawn was released. These provide rather striking examples of the care of fawns by female mule deer, and show that family ties are still strong up to a month before the fawning period, when the fawns of the past year are aggressively chased away by the does.

FOOD AND FEEDING HABITS

Spring and summer mule deer foods were determined largely by direct observation. When a feeding deer was seen, the place was noted and was visited after the deer had left, to see which plants had been sampled. In addition, eight rumen content samples were examined and the proportions of the various plants were estimated visually. Three of the samples were from the spring period and three from the summer and early fall. Two rumen samples were obtained in November, 1959. The degree of utilization of plants by mule deer from May to mid-September, compiled from direct observations is presented in Appendix A, while Appendix B summarizes the proportions of plants present in the eight rumen samples. Budd (1952), Clarke et al (1944), and Moss (1959) were used to identify the various plants.

Seasonal Differences in Food and Feeding Habits

1. Spring

When the snow disappears from exposed southwest slopes in the latter part of March, mule deer congregate there to partake of the first available green food. Grasses are the earliest plants to sprout and are closely cropped by mule deer, bighorn sheep, and elk. The new grasses are palatable to mule deer from the middle of April until the end of the second week in May, depending on whether the season is early or late. Cold spring weather may retard plant growth as much as two weeks.

By the end of the first week in May, forbs and shrubs begin to sprout and, by mid May, the diet has largely shifted from grasses to a wide variety of forbs and shrubs, the most important of which are cow parsnip, nodding onion, dandelion, geranium, false dandelion, larkspur, white camas, aspen poplar, and chokecherry. The scientific names of all plants appear in Appendices A. and B.

Toward the end of May, as vegetation on the north slopes and in sheltered situations begins to grow, the diet again shifts, this time to such plants as star-flowered Solomon's seal, strawberry, milkvetch, fireweed, vetchling, wild rose, aspen poplar, and willow. A similarly varied diet is known to be the case with mule deer in other areas (Einarsen, in Taylor, 1956).

The contents of rumen number one (Appendix B), taken from a buck found dead on May 14, 1957, are believed to be atypical. The movements of this deer had probably been restricted before its death, accounting for the high proportions of lodgepole pine and bearberry in the rumen. These species are not normally utilized in May.

2. Summer

During the summer, the proportion of forbs to shrubs in the mule deer diet decreases until, by August, shrubs compose the main type of food. The most important summer forbs are dandelion, milk-vetch, fireweed, hedysarum, and late yellow locoweed. Shrubs utilized throughout the summer, but particularly in July and August are wild

rose, chokecherry, willow, green alder, and black elder. The latter species is highly favored but poorly distributed.

3. Fall and Winter

Browse is known to be the chief type of food in the fall and winter diet of mule deer in other areas (Einarsen, in Taylor, 1956; Wilbert, 1958; Ratcliff, 1941). Cowan (1947) found that browse species composed 79 percent of the diet of mule deer in Jasper National Park in December of 1944. Bearberry composed 58 percent of the total food and buffaloberry (Shepherdia canadensis), a highly unpalatable species in the Sheep River area, made up 9 percent of Cowan's sample, suggesting an over-utilized range. Webb (1957) lists dwarf birch (Betula glandulosa) as an important big game browse species in Banff National Park.

Proceeding on the assumption that browse was the critical mule deer winter food, sample plots were surveyed in May of 1958 and, to a lesser extent, in May of 1959, after the method described by Aldous (1944). In May, 1958, an area of mixed grassland and aspen poplar habitat was surveyed (see map, Fig. 31). Circular plots, each covering 1/100 of an acre were outlined at intervals of 100 yards on transect lines which were 100 yards apart. On each plot, the browse species were tabulated and rated for density and degree of browsing. Only browse which was within reach of deer was considered. In addition pellet groups were counted to provide an indication of animal use.

Density ratings were recorded as dominant (50 to 100 percent), moderate (10 to 50 percent), and scarce (trace to 10 percent). Degree of browsing ratings were recorded as heavy (50 to 100 percent), medium (10 to 50 percent), and light (trace to 10 percent). For making convenient calculations, the average value for each rating was assumed, for example, 70 percent was used in the dominant category, 30 percent in the moderate category, and 5 percent in the scarce category. The seventy percent figure was felt to be closer to the average by Aldous and so, was used here. In 1958, 170 browse plots were sampled. The results of this survey appear in Table XIII.

In Tables XIII and XIV, the average density is calculated by dividing the total of the average density values by the total number of plots. The average degree of browsing is obtained by dividing the total average degree of browsing by the number of plots on which the species in question occurs. The utilization factor is derived by multiplying the average density by the average degree of browsing. The percentage of food eaten is found by dividing the utilization factor of a given species by the sum of the utilization factors, times 100. The percentage of browse available is found by dividing the average density of a given species by the total average density and multiplying by 100. The scientific names of browse plants appear in Table XVII.

Table XIII. Results of a browse survey of the aspen poplar-grassland type, May, 1958.

Common name	Percentage of plots present	Average density per plot	Average degree of browsing	Utilization factor	Percentage of food eaten	Percentage of browse available
aspen poplar	61.8	25.4	8.4	213.4	39.1	35.7
balsam poplar	13.5	3.8	0.4	1.5	0.3	5.3
lodgepole pine	6.5	1.4	11.4	16.0	2.9	2.0
wild rose	71.2	9.1	4.6	41.9	7.7	12.8
buckbrush	36.5	4.1	0.1	0.4	0.1	5.8
bearberry	8.2	2.3	0.4	0.9	0.2	3.2
gooseberry	29.4	3.1	0.1	0.3	0.1	4.4
shrubby cinquefoil	35.9	4.3	-	-	-	6.0
buffalo berry	7.1	1.5	-	-	-	2.1
wolf willow	7.6	1.0	5.8	5.8	1.1	1.4
white spruce	15.3	5.4	-	-	-	7.6
willow	5.3	0.3	21.7	6.5	1.2	0.4
chokecherry	15.3	3.3	62.3	205.6	37.6	4.6
pasture sage	21.2	3.3	0.1	0.3	0.1	4.6
juniper	2.9	0.4	6.0	2.4	0.4	0.6
rasberry	15.9	1.6	3.5	5.6	1.0	2.2
Douglas fir	0.6	0.2	5.0	1.0	0.2	0.3
saskatoonberry	5.9	0.7	62.0	43.4	8.0	1.0
green alder	0.6	trace	30.0	trace	trace	trace
Totals		71.2		545.0		

From Table XIII it can be seen that two species, aspen poplar and chokecherry, supplied 76.9 percent of the food eaten on the area surveyed. Aspen poplar was well distributed, but chokecherry represented only 4.6 percent of the browse available. Saskatoonberry made up 8.0 percent of the food eaten but only 1.0 percent of the browse available. Because of the absence of a widely distributed browse species of high palatability, the grassland-aspen poplar area is not a good winter range for mule deer. The two rumen samples collected on November 12, 1959 (Appendix B) were both taken from deer shot on this area. Both samples were composed mainly of browse, consisting largely of chokecherry, saskatoonberry, and aspen poplar, the three species found to make up most of the browse consumed in the grassland-aspen poplar type, in the survey of May, 1958.

Table XIV. Results of a browse survey of the lodgepole pine type, May, 1959.

Common name	Percentage of plots present	Average density per plot	Average degree of browsing	Utilization factor	Percentage of food eaten	Percentage of browse available
aspen poplar	43.8	10.2	19.6	199.9	23.1	12.1
balsam poplar	9.4	1.3	-	-	-	1.5
lodgepole pine	75.0	30.8	4.4	135.5	15.7	36.4
rose	62.5	4.7	0.8	3.8	0.4	5.6
buckbush	40.6	2.0	-	-	-	2.4
bearberry	9.4	0.5	-	-	-	0.6
gooseberry	18.8	0.9	0.8	0.7	0.1	1.1
currant	9.4	0.5	1.7	0.9	0.1	0.6
shrubby cinquefoil	15.6	1.6	-	-	-	1.9
buffalo berry	12.5	2.2	-	-	-	2.6
wolf willow	3.1	0.2	5.0	1.0	0.1	0.2
white spruce	37.5	12.7	-	-	-	15.0
willow	40.6	7.2	58.5	421.2	48.8	8.5
chokecherry	3.1	0.2	30.0	6.0	0.7	0.2
pasture sage	3.1	0.2	-	-	-	0.2
juniper	3.1	0.2	-	-	-	0.2
saskatoonberry	3.1	0.2	70.0	14.0	1.6	0.2
green alder	37.5	5.0	10.8	54.0	6.3	5.9
dwarf birch	3.1	0.9	30.0	27.0	3.1	1.1
bilberry	9.4	2.8	-	-	-	3.3
honeysuckle	6.3	0.3	-	-	-	0.4
Totals		84.6		864.0		

The more limited survey in the lodgepole pine habitat, conducted in May of 1959, showed that three species, aspen poplar, lodgepole pine, and willow, made up 87.6 percent of the food consumed on the area surveyed. Of these, willow was the only highly preferred species and comprised 48.8 percent of the diet of big game, even though it was poorly distributed, representing only 8.5 percent of the browse available. A large proportion of the willow is probably consumed by moose.

Table XV summarizes the pellet groups counted on the survey plots in the two different habitats. With the exception of horse and cow feces, only pellet groups which appeared to have been dropped during the previous winter were counted. Such pellet groups are distinguished by their darker color and lack of disintegration.

Table XV. Pellet groups on browse plots.

Cover type	Number of acres surveyed	Pellet groups	Number of groups per plot	Percentage composition						
				hare	cow	horse	mule deer	elk	moose	bighorn sheep
aspen poplar-grassland	1.70	387	2.3	2.1	5.7	11.9	52.6	15.8	0.3	11.6
lodgepole pine	0.32	93	2.9	20.4	5.4	-	46.2	5.4	22.6	-

If the defecation rates of mule deer, elk, moose, and bighorn sheep are comparable in some measure, then both the aspen poplar-grassland type and the lodgepole pine type received greater utilization by mule

Fig. 23. Chokecherry, badly over-utilized with many twigs dead or dying.

deer than by any other big game species. The presence of snowshoe hares in the lodgepole pine habitat represents an added drain on the supply of willow browse. The aspen poplar-grassland habitat surveyed was an area which, except for a few transients, was not used as cattle range. Cattle were pastured in a portion of the lodgepole pine area.

In September of 1958, the current year's growth of several browse species was tagged and measured. Each twig was tagged at the first node with a strip of white adhesive tape, numbered with pencil. The twigs were measured and recorded separately at a time when growth had stopped for the year. Species tagged were chokecherry, saskatoonberry, wolf willow, aspen poplar, and willow. In May of 1959, before growth commenced, the twigs were measured again to determine how much of the annual growth had been removed by browsing during the winter (see Figs. 24 and 25). These findings appear in Table XVI.

Table XVI. Degree of browsing on tagged browse during the winter of 1958-59.

Plant	Number of twigs tagged	Number of twigs browsed	Twigs browsed %	Fall-total available (inches)	Spring total removed (inches)	Available browse utilized %
aspen poplar	200	42	21.0	2,417.25	210.75	8.7
wolf willow	200	3	1.5	1,345.75	21.50	1.6
chokecherry	200	183	91.5	1,315.25	789.00	60.0
saskatoonberry	100	84	84.0	634.75	356.00	56.1
willow	99	99	100.0	1,597.50	1,349.75	84.5

Fig. 24. Tagged chokecherry twigs after heavy winter browsing.

Fig. 25. Tagged aspen twigs showing the effects of winter browsing.

In Colorado, Ratcliff (1941) estimated that 40 to 50 percent utilization of the annual growth of browse species was the maximum permissible, if the browse plants were to survive and reproduce. Mitchell (1941), however, suggests that most browse species can stand 60 to 70 percent utilization of annual growth. Einarsen (in Taylor, 1956) states that, if more than 60 percent of the annual growth is removed, browse plants and mule deer are adversely affected. Three of the five browse species tagged in the Sheep River area are badly over-browsed. These are chokecherry, saskatoonberry, and willow. Many chokecherry and saskatoonberry plants are dead and the remainder are unable to flower and bear fruit (see Fig. 23). Forty percent utilization of annual growth seems to be the maximum compatible with continued survival and reproduction of these two species. Willow is also over-utilized (note that all tagged willow twigs were utilized), but has tremendous powers of growth and can probably withstand 60 to 70 percent removal of annual growth. The high moose population in the Sheep River region is believed to be largely responsible for the over-utilization of willow.

Table XVII has been constructed after a scheme by Leopold et al (1951) rating the various browse species of the Sheep River area according to abundance and palatability. Question marks are used after species on which it was impossible to determine accurately the degree of browsing. This classification is based on direct feeding observations, results of the 1958 and 1959 browse surveys, analyses of rumen samples, and information obtained from browse tagging.

Table XVII . Palatability and abundance of browse species in the Sheep River area.

	Palatable	Less palatable	Unpalatable
Abundant		green alder (Alnus crispa sinuata) aspen poplar (Populus tremuloides) lodgepole pine (Pinus contorta) wild rose (Rosa spp.)	spruce (Picea spp.)
Moderately abundant	alpine fir (Abies lasiocarpa) dwarf birch (Betula glandulosa) willow (Salix spp.)	bearberry (Arctostaphylos uva-ursi)? wolf willow (Elaeagnus commutata)	pasture sage (Artemesia frigida)? buckbrush (Symphoricarpos occidentalis) currant (Ribes spp.) bilberry (Vaccinium sp.)? juniper (Juniperus spp.) shrubby cinquefoil (Potentilla fruticosa) rasberry (Rubus sp.)? buffalo berry (Shepherdia canadensis) balsam poplar (Populus balsamifera)
Scarce	chokecherry (Prunus virginiana) saskatoonberry (Amelanchier alnifolia) black elder (Sambucus melanocarpa) red-osier dogwood (Cornus stolonifera)	Douglas fir (Pseudotsuga menziesii)	limber pine (Pinus flexilis)

The Sheep River region lacks an abundant and palatable browse species which severely limits its value as a mule deer habitat. A great deal of browsing pressure on palatable, but less abundant, species has resulted in over-utilization and damage to the future food supply.

UTILIZATION OF MINERAL LICKS

Some workers in the past have approached the study of big game licks with the theory that animals using such licks, do so in search of a single compound or element (Cowan and Brink, 1949; Stockstad et al, 1953). As a result, conflicting results of lick analyses and mineral preference experiments in different regions have proven inconclusive. Stockstad et al (1953), working in Montana, concluded, on the basis of analyses of natural licks and preference tests, that sodium was the element sought by big game. Cowan and Brink (1949), on the other hand, analysed licks in Banff, Jasper, Kootenay, and Yoho National Parks and concluded that sodium chloride was not the compound sought in natural licks, and that certain trace elements might be preferred. Dixon (1939) analysed several mule deer licks and failed to accumulate any conclusive evidence to suggest a preferred element. The results obtained by Millar (1953) are similarly inconclusive. It is here suggested that perhaps there is no single element or compound being sought and no conscious desire on the part of mule deer to increase their consumption of essential minerals by using licks. It seems quite plausible that deer utilize licks because they are attracted by the taste of the salt or salts present in rather concentrated amounts. Salt may, in fact, represent a luxury item in the diet of mule deer. Human mineral requirements are largely satisfied by normal food intake and the same may be true of deer, since they also ingest traces of soil as well as vegetation. The

Fig. 26. Natural lick on Dot Mountain used mainly by mule deer. It is normally dry.

Fig. 27. Trails leading to the stock lick on the north fork of Gorge Creek.

suggestion by Cowan and Brink (1949), that big game animals may be seeking trace elements in licks seems unlikely, because it implies a sensitivity of taste which can distinguish between a single element present in trace amounts and the more common salts in the lick. Such taste discrimination has yet to be established for mule deer. If trace elements are sought by deer, the question arises as to why licks should be established at all, when many soils in the habitat of the mule deer might be expected to contain the same trace elements.

The location of mineral licks on the Sheep River study area is shown in Figure 1. Six natural licks were located during the course of the study. Four of these were sulfur springs and were used by mule deer only during the early part of May. Mule deer were seen licking in the Sheep River canyon on several occasions. Wishart (1958) reports that the minerals obtained by bighorn sheep in the canyon consist largely of magnesium salts. One dry natural lick, used almost exclusively by mule deer, was found (see Fig. 26). No analyses of lick samples were obtained.

Sodium chloride blocks, distributed during the summer months for cattle, were far more popular with mule deer than natural licks (Figs. 27 and 28). Although mule deer will lick the blocks of salt, they seem to prefer to eat the soil of the lick area, into which salt has been leached by rain. They will use such licks for two to three years after the addition of new salt has been discontinued, gouging large holes up to two feet in depth. According to Einarsen

Fig. 28. Another view of the same lick as in Fig. 28 showing the effect of trampling by cattle, moose, elk, and mule deer.

Fig. 29. Mineral cafeteria on the west slope of Dot Mountain.

(in Taylor, 1956), salt consumption by mule deer decreases in winter.

A total of 30 deer observed at stock licks in the Sheep River area remained for an average of 44 minutes, one licking for only four minutes, while another remained as long as 95 minutes. During the month of July, 1958, 10 deer arrived in the evening at the lick on the north fork of Gorge Creek (Figs. 27 and 28) at an average time of 8:17 P. M.

Two mineral cafeterias were erected on June 6 and 7, 1959. Plastic hand basins were used as containers and were fastened to a rack of aspen poles (see Fig. 29). Three pounds of soil were added to each basin and one pint of saturated salt solution was poured over each, after the method of Stockstad et al (1953). The following compounds were presented in a random manner, to the mule deer: copper sulfate ($CuSO_4 \cdot 5H_2O$), potassium biphosphate ($K_2HPO_4 \cdot 3H_2O$), sodium hypophosphate ($NaH_2PO_4 \cdot H_2O$), cobalt chloride ($CoCl_2 \cdot 6H_2O$), sodium bicarbonate ($NaHCO_3$), urea ($CO(NH_2)_2$), potassium iodide (KI), potassium chloride (KCl), sodium bisulfate ($NaHSO_4 \cdot H_2O$), sodium chloride (NaCl), ferrous sulfate ($FeSO_4 \cdot XH_2O$), magnesium sulfate ($MgSO_4 \cdot 7H_2O$), calcium carbonate ($CaCO_3$), sodium iodide (NaI), potassium phosphate ($K_3PO_4 \cdot XH_2O$), magnesium chloride ($MgCl_2 \cdot 6H_2O$), calcium chloride ($CaCl_2$), and potassium bicarbonate ($KHCO_3$). In addition, a control basin of soil and water was set up at each cafeteria. The results of the experiment were rather disappointing.

By June 17, 1959, all of the sodium chloride soil had been used at the first cafeteria and a trace of the sodium iodide soil had also been taken. The sodium chloride pan was refilled but was not touched again. None of the compounds in the second cafeteria was utilized during the summer. The limited use of the first mineral cafeteria and the observations of salt lick use, suggest that sodium chloride is the mineral most sought after by Sheep River mule deer.

Mule deer are known to eat shed antlers, presumably as a means of obtaining minerals (Linsdale and Tomich, 1953), but no evidence of this was noted during the present study.

Fig. 30. Photo taken from the top of South Volcano Ridge looking east. This is a very important elk wintering area at present.

INTERSPECIFIC RELATIONSHIPS

Competition between herbivorous animals almost invariably assumes the form of competition for food. This is the only type of competition of a critical nature in the life of Sheep River mule deer and is most severe in winter, the period of the year when many food plants are snowcovered and inaccessible. Relationships between mule deer and other animals also involve interspecific behavior of which several instances are noted below.

Elk (Cervus canadensis)

Elk competition has been held responsible for the decline and limitation of mule deer numbers in Idaho (McCulloch, 1955), Montana (Cole 1958 a, 1958 b), Oregon (Cliff, 1939), and Banff National Park, Alberta (Cowan, 1950). In Jasper National Park, Cowan (1947) found that elk competition increased throughout the winter. As the winter progressed and snow became deeper, elk food habits shifted from grass to browse, the staple food of mule deer.

Elk numbers in the Sheep River area have been increasing in the past few years, hence, competition with mule deer has probably increased, as well. Volcano Ridge (see Fig. 30) is now the most important elk winter range on the study area. During the course of the study, seven shed mule deer antlers were found in that area. All of the antlers were very old and badly weathered. Since no mule deer antlers of

recent origin were found on Volcano Ridge, it is possible that the numbers of mule deer wintering on this area have decreased in recent times, coincident with the increase of elk. Near Junction Lookout (see map, Fig. 1), a similar, though slightly higher area, eight shed mule deer antlers were found, all of recent origin. Few elk winter on the slopes around Junction Lookout.

Only one meeting of elk and mule deer was seen during the course of the study. On June 8, 1959, three buck mule deer and two bull elk were seen feeding near one another with no signs of intolerance. In this instance, the elk spotted the observer and moved away. This caused the mule deer to become alert but was not sufficient to cause them to flee.

Moose (Alces alces)

The moose population in the Sheep River region has increased beyond the carrying capacity of the range, but the degree of competition between moose and mule deer is unknown. The principal winter food of moose is willow, but dwarf birch and aspen poplar are also heavily utilized. Mule deer are known to eat aspen poplar in winter, but it is not known if they also depend on willow and dwarf birch. Moose are able to take much larger twigs than mule deer and thus, would be more effective competitors for any browse plants utilized by both species. Moose have the habit of "riding down" and breaking off aspen poplar and willow trees, usually killing the plant in the

process. A great deal of browse is destroyed in this fashion by permitting the entrance of fungi.

On two occasions deer were using a salt lick when moose happened along. In both cases, the mule deer moved aside to allow the moose full access to the lick area. Two male mule deer and a yearling moose were seen feeding adjacently without antagonism.

Whitetailed Deer (Odocoileus virginiana)

Only four whitetailed deer were seen in the Sheep River area during the three years of the study. Their relationship to the mule deer is unknown. No evidence of hybridization between the two species was found.

Bighorn Sheep (Ovis canadensis)

Wishart (1958) found little evidence of competition between mule deer and bighorn sheep except in spring, when both species are eating grass. Cowan (1947) reported that little competition existed between bighorn sheep and mule deer in Jasper National Park. Since the bighorn is primarily a grazer and the mule deer mainly a browser, little conflict should occur in the critical winter period. In April and May, however, both animals are feeding on new grass, the supply of which is, at first, limited. The competition involved may be responsible for slower spring recovery on the part of both species, perhaps causing the deaths of some weakened animals, that might have recovered, had

the spring competition been less severe.

Contacts between mule deer and bighorn sheep were seen only in May on the spring range. No signs of animosity, nor of friendliness, were noted between the two species. Groups of mule deer and bighorn sheep were often seen feeding together with apparent indifference to one another's presence. Such associations seem to be due to chance rather than to one species actively seeking out the other.

Cattle

Cattle are introduced into the Sheep River region each summer during the first week of June and are removed in early October. They are not serious competitors of mule deer in this area but do destroy a great deal of forage, largely through trampling. Streambank erosion is critical in some areas because the cattle tend to spend most of their summer in the valleys. The higher slopes are left for mule deer and other big game species. Cattle are primarily grazing animals, but do consume browse, notably willow, in late summer. Destruction of cover during the summer by cattle may be of some importance. It was noticed during the study that mule deer often spent the day at low elevations where cattle were absent, but rarely did so in areas where cattle had reduced the ground cover. Mule deer appear to avoid cattle at every opportunity. Some form of antagonism may exist between the two animals.

Horses

A small number of wild horses are present in the Sheep River area. In addition a few are maintained by the staff of the Sheep Ranger Station. Neither compete significantly with mule deer.

A high degree of compatability exists between horses and mule deer. On several occasions deer were seen grazing among the horses belonging to the staff of the Sheep Ranger Station. Deer will often allow a horse and rider to approach quite closely before taking flight.

Black Bears (Ursus americanus)

Two instances of mule deer behavior toward black bears were noted. On one occasion, a doe at a salt lick was approached by a bear. The doe bounded for 100 feet before turning to look back. She then moved unhurriedly away. The bear seemed to ignore her and proceeded in a different direction. Another time, two deer were feeding 100 yards from a bear that was occupied in turning over rocks and logs. Each party seemed to ignore the other.

Coyotes (Canis latrans)

On May 8, 1959, two deer were feeding on an open slope when a coyote appeared below them. The deer watched intently and moved toward the coyote. The coyote moved along the base of the slope,

apparently hunting Columbian ground squirrels (Citellus columbianus) while the deer resumed their feeding. On June 29, 1959, Mr. D. A. Boag observed a doe driving a coyote away with her forefeet until she had put him to flight. The doe then pursued for some distance. It was assumed that the doe was protecting a fawn hidden nearby, although none was seen.

Snowshoe Hares (Lepus americanus)

Snowshoe hares were rarely seen in 1957 but have since been increasing. They are not at present important competitors of mule deer, but their habit of girdling browse plants may further the decline of willow if they become overly abundant.

Columbian Ground Squirrels (Citellus columbianus)

Columbian ground squirrels are extremely keen of eye and, when danger is sighted, give an alarm call which is often sufficient to alert mule deer feeding nearby. The alarm calls of ground squirrels were never observed to stimulate deer to flight, but did cause general alertness and investigative behavior.

Magpie (Pica pica)

Two magpies were noticed on May 8, 1959, perched on the back and head of an adult doe. It is thought that they may have been

removing ticks which are common ectoparasites of mule deer in the spring. The doe seemed quite willing to accommodate the magpies. Browman and Hudson (1957) reported a similar relationship between mule deer and magpies.

Fig. 31. Map showing the location of mule deer remains and browse survey plots.

——— 1958 browse survey area

------ 1959 browse survey area

Mule deer remains:

♀ adult female

♂ adult male

● fawn

SCALE: 1 inch to 1 mile

Fig. 31. Map showing the location of mule deer remains and browse survey plots.

MORTALITY

During the course of the Sheep River study, the remains of 135 mule deer were found. An effort was made to record only those remains which seemed to belong to different animals. The sex and age composition of these remains appears in Table XVIII, while the locations of remains of known age and sex are plotted on the map (Fig. 31). Sexing and aging of remains is made difficult because predators, particularly coyotes, are inclined to carry away the skull portions. As can be seen from Figure 31, most of the mule deer remains were found in the vicinity of Missing Link Mountain. This was partly because this area was searched more intensively. It is thought that many of the mule deer which died in that region, did so in late winter and early spring, while awaiting the growth of spring vegetation. These deer died in open cover and their remains were less difficult to find than those of deer that died in heavier cover.

Mule deer were considered as fawns if the second molar was erupting and as yearlings if the third molar was erupting and the temporary premolars were not yet replaced. Deer with teeth in good condition were classed as mature adults, while deer with the infundibula on the first lower molars worn away were considered to be old adults. Of the mule deer remains that could be aged, 45.8 percent died as fawns, 6.7 percent as yearlings, and 47.5 percent as adults. Of the adult group, 56 percent were mature and 44 percent were old.

Table XVIII. Sex and age composition of mule deer remains found on the Sheep River study area

Sex \ Age	Fawns	Yearlings	Mature adults	Old adults	Unknown	Totals
Male	12	4	3	2	-	21
Female	7	2	19	13	-	41
Unknown	36	2	6	7	22	73
Total	55	8	28	22	22	135

Einarsen (in Taylor, 1956) states that on badly over-browsed range, immature deer make up 60 to 80 percent of the winter mortality. Over a period of years, immature deer in the Sheep River area have composed 52 percent of the total mortality, most of which probably occurred in winter. This figure approaches the mortality figures for a poor range set by Einarsen. The high proportion of mature adult remains found, suggests that some factor other than old age is responsible for mortality. This factor is believed to be malnutrition and will be discussed later.

Of the 19 fawn remains which could be sexed, 12 (63 percent) were males, suggesting the presence of a differential mortality, selecting against male fawns. This phenomenon has been noted in some other deer herds. Taber and Dasmann (1954) have shown with Columbian black-tailed deer, that 139 males die for every 100 females before the subadult deer reach 18 months of age. The authors suggested that certain behavioral traits, such as curiosity, might be exaggerated in male fawns, resulting in their greater demise. Longhurst and Douglas (1953) sexed 75 Columbian black-tailed fawns that died during their first winter and found that 51 were males and 24 were females. Robinette et al (1957), however, present fawn mortality figures of 97 males per 100 females for mule deer in Utah. Data for the Sheep River region are too scanty to permit conclusions to be drawn, regarding differential fawn mortality.

Thirty-five adult mule deer remains were sexed. Thirty (85 percent)

Fig. 32. Old adult doe that died during the winter. Remains were scattered by bears and coyotes.

Fig. 33. Remains of a mature adult doe as found in May.

of these were does and only five (14 percent) were bucks, suggesting a higher natural mortality of does than bucks. Hunting regulations prior to 1959 had been restricted to the taking of bucks only. This removal may have tended to reduce natural buck mortality.

Winter Mortality

Dead deer surveys were made each spring, from 1957 to 1959. Efforts were concentrated on the southwest slopes of Missing Link Mountain (Fig. 31), and all watercourses in this area were checked for dead deer. Deer that had died during the past winter were easily distinguished, even though they had, in most cases, been largely devoured and widely scattered by coyotes and bears (Fig. 32 and 33). Some deer had not died until the early spring (Fig. 34), having been weakened by the effects of the winter. During the last week in April, 1960, several days were spent on the study area and five recently dead deer were located. Winter mortality figures for the years 1957 to 1960 are presented in Table XIX.

Fig. 34. Mature adult buck that died of disease and malnutrition.

Table XIX. Age composition of deer that died in winter, 1957 to 1960.

Year of survey	Unidentified	Fawns	Yearlings	Adults			Total deer found
				mature	old	unidentified	
1957	4	11	3	4	1	4	27
1958	1	9	1	0	2	1	14
1959	0	4	0	0	0	0	4
1960*	1	1	0	3	0	0	5
Totals	6	25	4	7	3	5	50

* survey incomplete

Even in May, before the growth of vegetation has begun, deer remains are easily overlooked. For this reason, the figures in Table XIX do not represent actual mortality. A severe mule deer die-off occurred during the winter of 1956-57 and, in the spring of 1957, 27 deer remains were located. It was estimated that the total winter mortality for the study area was at least twice this figure. Four of the five adult deer that could be identified were mature. The death of mature animals may be symptomatic of a severe mule deer die-off caused by malnutrition. In the springs of 1958 and 1959, no mature deer were found dead. Mortality was moderate during the winter of 1957-58, 14 dead deer being found the following May. The winter of 1958-59 produced very light mortality and only four dead fawns were discovered in the spring of 1959. During the few days spent on the study area

in the spring of 1960, five dead deer were found, of which three were mature adults, suggesting that a fairly high mortality might have occurred the previous winter, despite the more liberal hunting season operative in November of 1959. Severinghaus (1947) found snow accumulations of 20 inches or more in depth to be critical for winter survival of white-tailed deer. The same may be true for mule deer, but no snow depth figures are available for the Sheep River area.

Summer Mortality

Mortality of adult mule deer in summer seems to be light. However, a considerable number of fawns may be lost through predation and weakness. The only dead deer found in summer on the study area were the remains of three fawns, only one of which was found during the period of study. Two fawn skulls appeared in the nest of a pair of golden eagles whose food habits were studied by Mr. D. A. Boag in 1955 (Wishart, 1958). It was impossible to determine the extent of summer fawn mortality because remains were seldom found. Summer mortality of adult and yearling deer is probably negligible.

Causes of Mortality

1. Hunting, Poaching, and Crippling Losses

During the 1957 and 1958 hunting seasons, only bucks could be legally taken in the Sheep River region. Twenty-five bucks were checked out from the entire Sheep District in 1957, but only 13 were checked in 1958. Hunter checks were incomplete and the actual kill was somewhat greater than recorded. In 1959, during the regular buck season, a special season of 4 days was held, during which mule deer of any sex or age could be taken. No checking figures were obtained, but about 30 mule deer are estimated to have been taken in the 1959 hunting season. Hunter success was greatly impaired by heavy snows which fell during the special either sex season. Hunting mortality was relatively light during the period of the study. If the 1959 hunting season was an indication, most bucks taken by hunters are yearlings.

The extent of poaching of mule deer in the Sheep River area is unknown, but is probably slight within the Forest Reserve. Outside the Reserve, however, poaching may be quite extensive.

Crippling losses have been demonstrated to be considerable in some areas, especially those where bucks only may be taken. In Utah, Costley (1948) found that in areas where bucks only were hunted, crippling losses represented 42 percent of the number of deer taken out, while on areas where either sex could be taken, crippling losses amounted to 25 percent of the deer recovered. No data are available

pertaining to crippling losses in the Sheep River District.

Six mule deer were collected during the study period, three in 1958 and three in 1959. These may be added to the hunting mortality for the two years.

2. Predation

Winter, particularly the months of January, February, and March, is the period when mule deer mortality is greatest, and is probably also the period of greatest predation. At that time of the year, when deer are weakened by malnutrition and hampered by deep snow, lighter predators which can walk on top of the snow have an advantage. It is thought that weakened animals are the first to succumb to predation (Einarsen, in Taylor, 1956). Leopold et al (1951) found that, as deer became weakened by malnutrition, they were unable to forage uphill and so drifted to lower elevations. In the Sheep River area, this would also mean that they would move to the areas where snow would be deepest and danger from predation greatest. On the study area, predators serve as a natural population check which could be utilized to assist in the reduction of the present mule deer herd to within the carrying capacity of its range.

A short period of predation occurs for up to three weeks after the fawns are born (Einarsen, in Taylor, 1956). The extent of such predation is unknown for the Sheep River area. Table XX

shows the predatory mammals seen during the course of the study from 1957 to 1959.

Table XX. Predatory mammals seen on the Sheep River study area, 1957 to 1959.

Year	Black bears	Coyotes	Cougars
1957	6	3	0
1958	21	7	1
1959	3	5	2

Bears

Black bears (Ursus americanus) are quite common on the study area, having been seen on 30 occasions from 1957 to 1959. Grizzly bears (Ursus horribilis) on the other hand, are rare and none were seen during the study period. Mr. D. A. Boag and Mr. W. D. Wishart saw a grizzly bear to the west of the study area in 1956. Grizzly bears may be dismissed as insignificant predators of mule deer in the Sheep River region. Black bears are probably not capable of capturing adult deer, except by accident. They may, however, be important predators of young fawns (Leopold et al, 1951) but the significance of this form of mortality could not be determined during the study.

Coyotes

The number of coyotes (Canis latrans) in the Sheep River District increased during the period of study. They were rather rare in 1957 but became common by 1959. In the early 1950's, coyotes in the Sheep River District were extensively poisoned as part of the provincial rabies control program. The coyote population was apparently just beginning to recover by 1957.

Coyotes have been found to be serious deer predators in other areas. They were thought to be limiting mule deer populations in Arizona (Kartchner, 1941) and California (Horn, 1941). In these instances, coyotes prevented the deer populations from increasing to the carrying capacity of their ranges. This is not the case in the Sheep River region where mule deer have exceeded the limits of the carrying capacity in spite of predation.

Coyote predation is undoubtedly most serious in winter when coyotes can travel easily on top of crusted snow, while the mule deer break through the surface. In the winter of 1957-58, ranger William Balmer shot two coyotes which were chasing a deer. This was the only reported instance of winter coyote predation on mule deer.

On June 1, 1955, Mr. W. D. Wishart (1958) saw two coyotes stalk a small group of deer without success. On June 29, 1959, Mr. D. A. Boag saw an adult doe repulse a single coyote by using her forefeet.

It would seem that an adult doe can successfully defend her fawns from one coyote, but might have more difficulty with coyotes in pairs.

In the spring of 1957, 51 coyote droppings were collected and, the following spring, 30 coyote feces were found. The hair found in the coyote scats was compared with that of museum skins. It was impossible to distinguish superficially between the hair of mule deer and that of bighorn sheep, but it is estimated that close to 90 percent of these droppings contained mule deer remains. The results of the analysis of coyote scats appear in Table XXI.

Table XXI. Analysis of coyote feces collected during the springs of 1957 and 1958.

Item	1957 (51)* Number of scats	1957 (51)* Occurrence (%)	1958 (30)* Number of scats	1958 (30)* Occurrence (%)	Two-year total (81)* Number of scats	Two-year total (81)* Occurrence (%)
mule deer and bighorn sheep	22	43	19	64	41	51
elk	4	7	0	-	4	5
moose	13	25	6	20	19	23
horse	1	2	0	-	1	1
showshoe hare	8	16	4	13	12	15
red squirrel	11	22	2	7	13	16
Microtine rodents	3	5	3	10	6	7
deer mouse (?)	0	-	1	3	1	1
pocket gopher	1	2	0	-	1	1
birds	4	8	0	-	4	5
moose tick	1	2	0	-	1	1
maggots	5	10	0	-	5	6
carrion beetles	1	2	0	-	1	1
grass	5	10	1	3	6	7
spruce needles	2	4	0	-	2	3
pine needles	0	-	1	3	1	1
bark	1	2	0	-	1	1
oats	0	-	1	3	1	1
unidentifiable	1	2	1	3	2	3

*Figures in brackets are numbers of scats analyzed.

If 90 percent of the feces in the mule deer-bighorn sheep category (Table XXI) actually contain mule deer remains as believed, then mule deer make up the largest single item in the winter and spring coyote diet. A large part of the mule deer eaten is undoubtedly carrion, but the exact proportion is unknown. Predation by coyotes is, at any rate, not sufficient to prevent the mule deer from suffering malnutrition during the winter.

Wolves

Only one wolf (Canis lupus) has been seen in the Sheep River area since the Alberta Biological Station opened in 1950 (Wishart, 1958). It can safely be assumed that there is no resident wolf population in the Sheep River area.

Cougars

The cougar (Felis concolor) has long been known as an efficient killer of mule deer, but opinions vary as to the extent of such predation. Cougars were rarely seen in the Sheep River area prior to 1957. Wishart (1958) reported that only four had been seen in the region in recent years. A sudden influx seemed to occur in the winter of 1957-58 when nine cougars were shot in the Sheep District. One was seen during the summer of 1958 and another was shot in the winter of 1958-59. Two were seen in the summer of 1959 and one of these was shot. The greater numbers of cougars present seemed to

have no noticeable effect on the mule deer population, which increased during the three years. Cougars are extremely wary and difficult to see, hence the size of the cougar population on the study area could not be estimated.

Lynx

The abundance of lynx (Felis canadensis) in the Sheep River region was difficult to determine. None was seen during the period from 1957 to 1959, but one was seen in the summer of 1956. Lynx, like cougars, are seldom seen, but tracks were noted on several occasions. A lynx kill discovered by assistant ranger Rae Hill in the winter of 1956-57 was the only authentic case of predation on mule deer during the period of study. Mr. Hill found the remains of a freshly killed fawn with lynx tracks leading away. Since no tracks led to the kill, Mr. Hill concluded that the lynx had ridden on the back of the fawn before killing it. Working in the Southern Appalachian Mountains, Progulske (1955) found that white-tailed deer comprised the third most important food item in the diet of the bobcat (Felis rufus), a close relative of the lynx. The latter do not seem to be sufficiently abundant on the Sheep River study area to be considered as major mule deer predators.

Wolverines

One wolverine (Gulo gulo) was seen west of the study area by Mr. W. D. Wishart and Mr. D. A. Boag in the summer of 1957. These animals are apparently very rare and, thus, are not important mule deer predators.

Golden Eagles

Leopold et al (1951) cite three records of golden eagles (Aquila chrysaetos) attacking mule deer fawns. It is doubtful if the birds ever prey on adult deer. During the summer of 1955, Mr. D. A. Boag recorded the food items brought to a golden eagle nest on Missing Link Mountain (Wishart, 1958). Two out of eighty-seven items were fawn skulls. Whether these fawns represented carrion or were actually killed by the eagles was not determined. It seems quite possible, however, that they were examples of eagle predation. In the summer of 1958, two eagles again nested on Missing Link Mountain but this time, no mule deer remains were found in the nest. The chief food of the golden eagle in the area is the Columbian ground squirrel (Citellus columbianus). Although eagles may kill an occasional fawn, they are not detrimental to the deer population in the area.

3. Parasites and Disease

Parasites were recovered from six mule deer, one of which was found shortly after it had died. With the exception of the deer nose bot, Cephenemyia jellisoni, no parasites were definitely found to have a harmful effect on the hosts. The various parasites and the degree of infestation of each are presented in Table XXII.

Table XXII. Parasites of Sheep River mule deer.

Degree of infestation: + light, ++ moderate, +++ heavy

	Location	Deer number					
		1.	2.	3.	4.	5.	6.
Endoparasites							
Cestodes							
Taenia sp. (cysts)	lungs, mesenteries	++	+			+	
Hydatigera sp. (cysts)	mesenteries, liver				+	++	++
Moniezia benedeni (?) (adult)	ileum			+			
deer nose bot							
Cephenemyia jellisoni (larvae)	nasopharynx			+++	+++		
Ectoparasites							
Dermacentor albipictus	most common behind the ears and under the tail		++	++	++		

According to Dr. J. C. Holmes, who identified the parasites, the cysts of Taenia sp. and Hydatigera sp. did not agree with published material and will require further investigation before their taxonomic status can be determined. Neither appears to weaken the host in any way, although no heavy infestations were encountered.

The adult tapeworm was poorly preserved, but may have been Moniezia benedeni, a species which, according to Honess and Winter (1956) can be a serious parasite of mule deer causing diarrhea, emaciation, degeneration of the liver and spleen, and congestion of the kidneys in severe cases.

The larva of the nose bot, Cephenemyia jellisoni was the most serious parasite encountered. In the spring of 1958, the mule deer population of the Sheep River area was heavily infested. The parasites live in the nasopharyngeal region and cause considerable discomfort to the deer, who sneeze frequently because of the irritation. There was indication that a heavy infestation of this parasite impaired the sense of smell of the mule deer. According to Honess and Winter (1956), nose bot larvae weaken the host in the late winter, the time when nutritional levels are lowest.

The moose tick, Dermacentor albipictus, is said to be an important parasite of deer, elk, and moose causing weakening, nervousness, and emaciation in severe infestations (Honess and Winter, 1956). No heavy infestations were encountered, but the Sheep River mule deer are bothered considerably by this tick in the

spring when they have been observed scratching and rubbing spots where the ticks are attached. When the tick has been rubbed off, a scab about the size of a ten-cent piece is left on the skin of the host. Moose ticks commonly attack behind the ears of mule deer where they are not easily removed by their host.

An adult buck found dead on May 14, 1957 was thought to have died of malnutrition complicated by an unidentified liver ailment. About one-quarter of the liver had been replaced by areas of cream-colored tissue. Normal liver processes were probably greatly impaired.

On July 5, 1957, a yearling doe was seen with several "hanging warts" or papilloma-like structures on the right shoulder and neck. Two of the growths were as large as oranges. Otherwise, the deer seemed to be in good condition. According to Leopold et al (1951) and Honess and Winter (1956), such growths are not pathogenic and may appear and disappear over a period of time. Occasionally they grow near the eyes of mule deer causing blindness.

An adult doe with a large swelling on her left hind ankle, seen on several occasions, apparently did not suffer from the abnormality. The growth may have been caused by an injury.

In May of 1958, an adult doe in very poor condition was seen. Her coat was rough and dull-colored and she was badly emaciated. Both sides of her face were noticeably swollen. This may have been a case of lumpy jaw caused by the fungus Actinomyces necrophorus which, according to Cass (1947), often gains entry through a mouth injury

caused by coarse forage. Lumpy jaw is often fatal. Only one skull collected from the Sheep River area showed any indication of necrosis of the bone, such as is caused by Actinomyces necrophorus. This one example was not a serious case. The incidence of the disease seems to be rare in the area.

4. Accidents and Injuries

According to Cronemiller and Bartholemew (1950), accidental falls, particularly in canyons, are known to be a significant mortality factor among mule deer in California. No such instance of mortality was noted in the Sheep River area, but deer do utilize the Sheep River canyon as a mineral lick and may be subject to such accidents on occasion.

Assistant ranger Joe Machovec reported that an adult doe, found dead in March of 1960, had apparently died accidentally. A large rock was found in the abdominal cavity. The rock was thought to have rolled down the slope and struck the deer.

While driving to Turner Valley at dusk, Mr. Edgar Allin startled a doe on the road. She dashed to one side and collided with a barbed wire fence. She bounced back unhurt and then went through the fence, but the accident might have been more serious had the deer become entangled.

Two crippled adult does were seen during the study. The lameness in both cases appeared to have resulted from an injury,

perhaps a twisted joint.

Many deer are seen with scars on the abdominal region, probably the result of snagging on twigs or barbed wire while running. If such an injury were severe enough to puncture the abdominal wall, death might result.

Accidents and injuries are probably not important factors in mule deer mortality.

5. Malnutrition.

Since the author was not present on the study area during winter, it was impossible to determine the exact role of malnutrition in the mortality of Sheep River mule deer. However, it was noted in May that most mule deer appeared very thin and in generally poor condition. Because of the over-browsed conditions of the most palatable browse species in the area, it is believed that malnutrition is prevalent in the herd during late winter. Einarsen (1946) has shown that protein levels of browse plants drop as the winter progresses, just as do deer weights. Malnutrition may result from this natural decline of protein levels plus the difficulty which the deer encounter in obtaining high quality browse as snow depth and degree of browsing increase.

Malnutrition need not cause mule deer mortality directly to be of importance. It also increases the incidence of the other natural mortality factors. Weakened deer are more prone to accidents

and may become entangled in fences or fall more easily (Leopold et al, 1951). Deer suffering from malnutrition provide easy prey for predators that would normally capture them only with great difficulty. In addition, starving deer are less able to resist the debilitating effects of parasitism (Longhurst and Douglas, 1953). McEwen et al (1957) obtained interesting results when feeding penned white-tailed deer a special diet. These authors found that deer fed on a constant diet ate less in winter than in summer and, as a result, lost weight. If this same phenomenon is operative in wild deer, it should be taken into account when assessing deer weight losses during the winter.

Limiting Factors

The factors limiting the Sheep River mule deer population can be briefly summarized. The increase of mule deer in this area is prevented by an inadequate supply of winter food, primarily browse. An abundant browse species of high quality is lacking in the region and, it seems unlikely that a high density of mule deer can ever be attained for this reason. Competition from elk and moose for the existing browse supply has further aggravated the situation. Possible remedies for this problem are presented in the next section.

MANAGEMENT

Present Policy

The present management policy for mule deer in the Sheep River area is one of extreme caution. There are two reasons for this approach. Public opinion is the first of these. Many Alberta sportsmen are still steeped in the wildlife conservation policies of twenty years ago which, briefly stated, entailed the shooting of bucks only, short seasons, minimal bag limits, and rigid predator control. The present excessive population of mule deer, elk, and moose remains unrecognized by many sportsmen. The second reason for the cautious approach to mule deer management is the lack of sufficient personnel and finances to enable the Alberta Fish and Game Branch to make the intensive annual surveys necessary for the proper management of mule deer and other big game.

The first antlerless mule deer season to be held in the Sheep River District in recent times was conducted for four days in November of 1959, during which time ranger R. Mustard and his staff conducted as complete a hunter check as was possible with limited facilities. Aerial surveys are flown over the area in winter, but are mostly of value in censusing elk. Hunting seasons and bag limits in the area are based largely on the incomplete hunter check made during the previous hunting season.

Recommendations

The most pressing need in the Sheep River region is the reduction of mule deer, moose, and elk to within the carrying capacity of the range. Deer and moose, especially, will be subject to decimation during the next severe winter unless their numbers are reduced. If this is to be accomplished by hunting, either-sex seasons must be introduced at the start of the season, rather than in November as in 1959. Bad weather in November often prevents an adequate harvest of big game. If either-sex seasons alone are insufficient to reduce the herds, longer seasons, earlier seasons, increased bag limits, and lower restrictions on non-resident hunters could be introduced. There seems little or no chance of a single hunting season proving permanently detrimental to mule deer in the Sheep River area because most of the region is inaccessible by road.

If the mule deer herds are to be reduced properly, at least two types of field survey must be employed annually. Complete hunter checks should be made during the hunting season. This should be a relatively easy matter, since there are only two access roads to the entire Sheep District, and the only requirement is that a man be on duty at each of these points at all times. Secondly, at least one census of the mule deer population must be made each year. The best time for such a census would seem to be from April until the middle of May, when the deer are in the open and the deciduous vegetation has not yet begun to leaf out. The census could be done

by air or by automobile and would be best performed in the morning or evening. Aerial census might be most satisfactory after a light snowfall. Such an annual spring census would evaluate the huntable population for the coming fall, since little summer mortality occurs.

Winter feeding of mule deer has been shown to aggravate, rather than alleviate, over-population problems in other areas (Carhart, 1943). If hunting fails to reduce the mule deer, moose, and elk populations, perhaps the removal of predators from the area should be discontinued to increase natural mortality.

Once the antlered game populations have been reduced, they should be maintained at a level slightly below the carrying capacity of the range, to allow over-browsed species such as chokecherry, saskatoonberry, and willow to recover and reproduce. In the future, the introduction of favorable browse species, such as red-osier dogwood, might be attempted on an experimental basis, with a view to increasing the mule deer carrying capacity. It is realized that all management policy must be dependent on the allocation of Provincial Government finances.

SUMMARY

1. The ecology of the Rocky Mountain mule deer, Odocoileus hemionus hemionus (Rafinesque), was studied in the summers of 1957, 1958, and 1959 at the Alberta Biological Station. The study area was located in the high foothills, 18 miles west of Turner Valley, Alberta, where lodgepole pine (Pinus contorta var. latifolia) and aspen poplar (Populus tremuloides) were in the early stages of succession to spruce (Picea spp.).

2. Adult mule deer weights increased by one-quarter to one-third between May and September.

3. The red summer pelage appeared during the month of June, while the gray winter pelage became apparent in the month of September.

4. Mule deer densities ranged from 5.6 per square mile in 1957 to 7.2 per square mile in 1959.

5. For the three years, the adult sex ratio averaged 29 males per 100 females.

6. Overwinter survival of fawns averaged 41 per 100 does.

7. The rut occurred during the month of November and parturition reached a peak during the second week in June.

8. Fawns began to accompany the does in late July and early August and lost their spots by September.

9. The number of fawns per adult doe, seen from August 8 to September 8, averaged 0.7 for the three years, but the actual ratio was believed to be higher.

10. Antlers on adult bucks developed the primary fork by the third week in June and the secondary forks by the second week in July. Adult antlers were completely formed by the first week in September.

11. Average size of mule deer groups decreased from May to June, but increased from August to September.

12. The average size of buck groups was 1.6.

13. Little or no winter migration seemed to occur in the Sheep River herd.

14. Spring feeding aggregations gathered on southwest slopes during the months of April and May, but dispersed by early June.

15. Four deer were trapped and tagged. The spring ranges of three does were delimited.

16. In May, mule deer activity continued throughout the day, but during the rest of the summer, was largely confined to the early morning and evening periods.

17. Observations of individual and group behavior were presented.

18. The chief mule deer foods were discussed. Food in May consisted of grass and forbs. In summer, mule deer ate forbs and browse and in fall and winter mainly browse.

19. Chokecherry (Prunus virginiana), saskatoonberry (Amelanchier alnifolia), willow (Salix spp.), and black elder (Sambueus melanocarpa) showed severe over-utilization.

20. The Sheep River area lacked an abundant browse species of high palatability.

21. The results of two mineral cafeterias were inconclusive, but observations suggested that sodium chloride was preferred.

22. Chief mule deer competitors were elk and moose.

23. Of all deer remains found, 45 percent were fawns, 7 percent were yearlings, and 48 percent were adults.

24. Twelve of 19 dead fawns were males.

25. Twenty-seven deer were found dead in the spring of 1957, fourteen in 1958, and four in 1959.

26. Hunting pressure was light. Malnutrition and predation accounted for most of the remaining mortality.

27. The primary limiting factor was the present over-population of a winter range which had a low carrying capacity.

28. Reduction of moose, elk, and mule deer by means of increased hunting pressure and decreased predator control was strongly recommended. In order to harvest big game in the area properly, complete hunter checks and annual big game surveys must be conducted. Spring was suggested as the best time to count the mule deer population in the Sheep River area.

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APPENDIX A

Spring and summer foods of Sheep River mule deer based on direct observations.

H--heavy utilization M--moderate utilization L--light utilization

Common name	Scientific name	May	June	July	August to September 15.
GRASSES AND GRASS-LIKE PLANTS					
bluegrasses	*Poa* spp.	H	-	-	-
brome grasses	*Bromus* spp.	H	-	-	-
Parry oat grass	*Danthonia parryi*	M	-	-	-
fescue	*Festuca* spp.	M	-	-	-
wheat grasses	*Agropyron* spp.	M	-	-	-
timothy	*Phleum pratense*	M	-	-	-
June grass	*Koeleria cristata*	M	-	-	-
sedges	*Carex* spp.	L	-	-	-
FORBS					
dandelion	*Taraxacum* sp.	M	H	H	L
milkvetch	*Astragalus* spp.	M	M	H	H
fireweed	*Epilobium angustifolium*	M	H	M	M
vetchling	*Lathyrus ochroleucus*	H	H	L	L
hedysarum	*Hedysarum* spp.	L	M	H	H
wild red raspberry	*Rubus* sp.	L	M	L	-
late yellow locoweed	*Oxytropis campestris*	-	L	M	M

APPENDIX A (Cont'd)

Common name	Scientific name	May	June	July	August to September 15.
strawberry	Fragaria glauca	L	L	L	-
cow parsnip	Heracleum lanatum	H	L	-	-
star-flowered Solomon's seal	Smilacina stellata	M	L	-	-
white clover	Trifolium repens	M	L	-	-
paintbrush	Castilleja sp.	-	L	L	-
crocus anemone	Anemone patens	L	L	-	-
white camas	Zygadenus elegans	H	-	-	-
nodding onion	Allium cernuum	M	-	-	-
wild geranium	Geranium spp.	M	-	-	-
false dandelion	Agoseris sp.	M	-	-	-
larkspur	Delphinium sp.	M	-	-	-
American vetch	Vicia americana	L	-	-	-
showy aster	Aster conspicuous	-	-	-	L
SHRUBS AND TREES					
willow	Salix spp.	M	H	H	H
wild rose	Rosa spp.	M	H	H	H
chokecherry	Prunus virginiana	M	M	M	M
aspen poplar	Populus tremuloides	M	M	-	-
lodgepole pine	Pinus contorta var. latifolia	L	-	-	-

APPENDIX B

Rumen contents of eight Sheep River mule deer.

H--high proportion M--present in moderate amounts T--present in trace amounts

Common name	Scientific name	Rumen number* 1.	2.	3.	4.	5.	6.	7.	8.
GRASSES	GRAMINEAE	T	H	H	T	-	-	-	-
FORBS									
cinquefoil	Potentilla sp.	-	T	-	-	-	-	-	-
dandelion	Taraxacum sp.	-	T	M	-	-	-	-	-
buttercup	Ranunculus sp.	-	T	-	-	-	-	-	-
northern bedstraw	Galium boreale	-	T	T	-	-	-	-	-
strawberry	Fragaria glauca	T	-	-	-	-	T	-	-
bluebur	Lappula echinata	-	-	T	-	-	-	-	-
wild geranium	Geranium sp.	-	-	T	T	-	-	-	-
horse mint	Monarda fistulosa	-	-	T	-	-	-	-	-
gaillardia	Gaillardia aristata	-	-	T	-	-	-	-	-
aster	Aster sp.	-	-	-	T	-	-	-	M
hedysarum	Hedysarum sp.	-	-	-	-	H	-	T	-
fireweed	Epilobium angustifolium	-	-	-	-	-	M	T	-
SHRUBS AND TREES									
aspen poplar	Populus tremuloides	-	T	M	-	-	T	M	M
white spruce	Picea glauca	-	T	-	-	-	-	-	-
bearberry	Arctostaphylos uva-ursi	M	T	-	-	-	-	-	-

APPENDIX B (Cont'd)

Common name	Scientific name	1.	2.	3.	4.	5.	6.	7.	8.
lodgepole pine	Pinus contorta var. latifolia	H	-	-	-	-	-	T	T
green alder	Alnus crispa sinuata	T	-	-	-	T	H	-	-
chokecherry	Prunus virginiana	-	-	M	-	-	-	H	H
saskatoonberry	Amelanchier alnifolia	-	-	M	-	-	-	M	M
willow	Salix spp.	-	-	M	M	M	M	-	-
red-osier dogwood	Cornus stolonifera	-	-	-	T	-	-	-	-
wild rose	Rosa spp.	-	-	-	H	T	-	-	-
buckbrush	Symphoricarpos occidentalis	-	-	-	T	-	-	-	-
black elder	Sambucus melanocarpa	-	-	-	-	M	T	-	-
MISCELLANEOUS									
leaf gall		-	-	-	T	-	-	-	-
red plastic seismic flag		-	-	T	-	-	-	-	-

* Collection dates of rumen samples.

1. May 14, 1957 (found dead).
2. May 8, 1958.
3. May 14, 1958.
4. September 4, 1958.
5. July 19, 1959.
6. August 26, 1959.
7. November 12, 1959.
8. November 12, 1959.